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TRANSACTIONS

OF THE

GEOLOGICAL SOCIETY OF GLASGOW.

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TRANSACTIONS

OF THE

GEOLOGICAL SOCIETY

OF GLASGOW.

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The Editor begs to state that the Authors are alone responsible for the facts and opinions contained in their respective papers.

R. Anderson, Printer Glasgow.

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TRANSACTIONS

OF THE

GEOLOGICAL SOCIETY OF GLASGOW.

I.—*On the* Fossils *of the* Upper Series *of the* Lower Carboniferous Limestones *in the* Beith and Dalry Districts *of* North Ayrshire. By Robert Craig, Langside, Beith.

[Read 12th October, 1876.]

The beds under review.—The upper series of the lower Carboniferous limestone consists of a series of beds varying in thickness from one foot and upwards, rarely reaching above 4 feet. At Trearne, Beith, their total thickness, when all on, is about 40 feet. The beds in this section, which may be taken as a typical one, are of a lenticular character, interbedded with thin bands of shale, which partake of the same irregularity. These irregular bands of intervening shale are characteristic of the series, wherever found, and are more abundant in the lower half of the group, dying out as the upper beds are reached. The return, at lesser or greater periods, to the shale-producing conditions, has caused this fine deposit of marine limestone to be divided into a series of beds; the shale bands being often not more than half an inch in thickness, and, with few exceptions, never rising above 6 inches. It is beyond the scope of this paper to inquire into the cause of these changes in the ancient Carboniferous sea which have produced these shales, but, in passing, it may be remarked that, after much observation, I have come to the conclusion that volcanic dust has had more to do with their formation than geologists have yet given credit for. Many of them have a greenish tinge, and others, when newly split up, are strongly marked with the same colour, while their composition is calcareous to the extent of one half.

Physical aspect and extent of area investigated.—The group has been wrought at Trearne, Hillhead of Broadstone, Dockra,

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Gatend, and Oldmill, also at North Biggart, Beith. The three former quarries have been, and still are, extensively worked; during the last thirty years nearly as many acres have been removed, and good opportunities for observation afforded. The upper limestone rests upon the shales that divide the lower limestone into two series of beds—(see my paper, Transactions Geol. Soc. of Glasgow, Vol. V., page 42). The series has also been wrought at Auchencloich, Kilbirnie; Howrat, Cunningham-Baidland, and Auchenskeoch, Dalry; Cartleburn and Auchenmade, Kilwinning; Waterland and Gameshill, Dunlop; and Peacockbank, Stewarton. Other workings have been opened, but these are the principal, and take in a superficial area of nearly 50 square miles. The greatest departure from the physical character of the typical beds of Trearne, is found on the west side of the basin at Auchencloich, and at Howrat quarries north of the farm house. In these sections crinoid stems are rare, and the limestone is of a very fine structure, splitting with a smooth fracture. It is in the same bedded form as at Trearne and elsewhere, but in some of the beds a mixture of mud with the calcareous matter makes them useless for the manufacture of lime. This condition appears to be local, and confined to the north-west edge of the basin, as in the quarry section south of Howrat farm-house crinoids and brachiopods are nearly as abundant as at Trearne. The beds in the above sections, where wrought, have a total depth of from 20 to 24 feet, but below this there is a depth of beds, formed of calcareous shale with thin bands of limestone, of more than 40 feet; so that the whole depth of the calcareous deposits here is not less than at Beith.

Palæontographical aspects.—In noticing the fossiliferous character of these beds, I have divided the series into an inferior and a superior one, merely for convenience of description, as little difference of character is noticeable throughout the group; a thin coral band is made the line of division.

At Trearne the beds are entirely built up of crinoids, brachiopods, and other remains of marine fauna. Although one mass of organic remains, from the indurated character of the rock good cabinet specimens are not easily detached from the matrix; still, by a careful use of the hammer, a few can be procured; but it is from the bands of intercalated shale, when weathered in the refuse heaps, that the collector receives his best specimens.

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Protozoa.—In all of the sections, *Hyalonema Smithii* is mixed up in the limestone. In some of the beds it is moderately common, in others it is absent, and again in others it is found rarely. It was in the Cunningham-Baidland section that Mr Smith, of the Eglinton Iron Works, first discovered *Hyalonema Smithii*, Y. and Y., the spicula appearing to be very abundant; this species is also found at Trearne and Waterland, though specimens are very rare.

Actinozoa.—The corals are all but absent from the purer limestone beds of the series. At Waterland and Cunningham-Baidland four thin bands of *Lithodendron fasciculatum*, Flem., are found interbedded in the group of limestones, and at Trearne a bed of impure limestone, full of the same corallite, is found near the base of the series, and this is also present on the same horizon at Dockra and Nettlehurst. At Hillhead, a band of rugose corals is found at about the same horizon, and in it a few genera and species are abundant, amongst them being principally the following:—*Amplexus coralloides*, Sow., *Campophyllum Murchisoni*, M. Edw., *Zaphrentis Bowerbankii*, M. Edw., *Z. nodulosa*, Phill.

Echinodermata.—Of the Echinoidea, *Archæocidaris Urei*, Flem., is the most abundant, plates and spines being found in most of the sections. At Hillhead and Cunningham-Baidland they are rather abundant in certain places, in a bed of white limestone lying on the same horizon as the polyzoan bed at Trearne, and they may be detected in any of the beds, although rare. They also occur at Waterland and Dockra, along with *A. Münsteriana*, De Kon.

Although this group of limestone beds, with a few exceptions, is almost entirely built up of the broken stems of crinoids, from the absence of heads and entire specimens it is almost impossible to identify the genera and species, and at present I am not prepared to give a full list of all the crinoids found in the series. The following genera have been identified, *Actinocrinus*, *Pisocrinus*, *Poteriocrinus*, *Platycrinus*, and *Rhodocrinus*. Stems 1 inch or more in diameter, are not rare at Trearne, and in the other Beith sections; the crinoids of the lower limestone appear here to have reached their maximum of growth. With the exception of Howrat north section, and that of the Puduff burn, and a few beds of the Auchenskeoch section, crinoid stems are the principal fossil constituents of these beds.

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Crustacea.—Trilobites are rare in the series, a few fragmentary specimens of *Griffithides mesotuberculatus*, M'Coy, being occasionally met with in all the sections, while upon the top beds of Howrat north section *G. Eichwaldi*, Fischer, is rather abundant; but of all the organic remains found in the lower limestone, if taken throughout, this one is the rarest in comparison of number. Throughout the white band of limestone in the Trearne quarry two species of *Cyclus*, one of them new, have been found. Here also have been obtained many species of the larger entomostraca noted in the list. These I found to be plentiful in one of the lenticular beds of the white limestone. Several of the species of these entomostraca are new to the strata of this district, while other species have not hitherto been found in the Carboniferous limestone strata of Scotland.

Polyzoa.—Upon the surfaces of the limestone beds, and in the shale bands, specimens of polyzoa are found in all the sections, and in all the beds of the group. In the Beith quarries, in the inferior beds of the series, good cabinet specimens are rare, and this is generally the case except at Auchenskeoch. In the shales of the latter quarry, some fine specimens have been procured; at Hillhead and Waterland, a shale, full of *Streptorhynchus crenistria*, is rich in *Fenestella* and *Polypora*. A band of shale at Trearne, and a bed of white limestone in the superior division of the series, is also rich in these and other genera, as may be seen from the lists appended.

Brachiopoda.—Next to the crinoids, and in some places supplanting them in numbers, are the brachiopods, which throughout the sections are very abundant, some of the beds being almost built up of *Productus*, *Spirifera*, and *Terebratula*. At Trearne and Hillhead, *Athyris Royssii*, Lév., is very abundant in the inferior beds. In them some fine specimens are found, and it is not a rare shell in any of the sections. *Chonetes*, *Crania*, *Discina*, and *Orthis* are all rare in these sections, although present in them all. All these, *Orthis* perhaps excepted, appear to have inhabited a muddy sea bottom, and are more abundant in the shales than in the purer limestones. Two specimens of *Discina Craigii*, Davidson, have been found in the limestone, which appears to have been the habitat of this rare species. The *Producti* most abundant are *P. costatus*, J. de C. Sow., *P. fimbriatus*, J. de C. Sow., *P. giganteus*, Mart., *P. longispinus*, Sow., *P. punctatus*, Mart.,

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P. scabriculus, Mart., *P. semireticulatus*, Mart., *P. spinulosus*, Sow., *P. Youngianus*, Dav., and their varieties. The other species present are rarer, although at Howrat, *P. cora*, D'Orb., is one of the most abundant. Two species of *Rhynchonella* are present, although not in abundance; *R. pugnus*, Mart., is rather rare; *R. pleurodon*, Phill., is not uncommon in some divisions in the limestone. The *Spiriferæ* are present in all the sections, the more common being *S. duplicicosta*, Phill., common at Waterland, Hillhead, and Cunningham-Baidland; *S. glabra*, Mart., in all the sections; *S. lineata*, Mart., the same; *S. trigonalis*, Mart., and its variety, *bisulcata*, Sow., is also well represented throughout. The other species of this genus are of rarer occurrence, but both *S. pinguis*, Sow., and *S. ovalis*, Phill., are not very rare at Trearne and Auchenmade, although good specimens are not plentiful. *Streptorhynchus crenistria*, Phill., is abundant in both limestones and shales, especially in beds about the middle of the series. A bed of shale on this horizon, at Hillhead, Gatend, and one near the top of the superior beds at Cunningham-Baidland, are in a great measure made up of them, they are in such profusion. Two species of *Terebratula* are abundant in most of the beds, but they are very diminutive when compared with their analogues of the blue limestone sub-series, or with those of the upper limestone, Linn Spout, Dalry. This is very apparent in the Beith sections; at Howrat, they are a little larger than at Beith, but, on the whole, very inferior in size to those found in the above beds, which is the more curious, as the *Producti* are larger in this series than in either the sub-series or the upper limestone. These comprehend the most of the brachiopoda present in the group, and when summed up amount to 13 genera, and 39 species, and 15 varieties. I have no doubt a few more will yet turn up, as the quarrying operations proceed. Additions are always being made, but in the meantime these comprehend the number of the genera and species common to the series.

Lamellibranchiata.—This group is but poorly represented. It does not abound in the purer limestone of the district, being confined to the argillaceous shales and the intercalated shale bands, the shale-creating conditions having been of too short duration to allow the income and spread of imigrants from this class. At Howrat and Auchencloich, where the shales are heavier, the group is more largely represented than in the other sections, and this

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holds good wherever the same conditions are present. *Pinna flabelliformis*, Mart., is the most common, being found in all the sections, although almost invariably crushed. At Trearne, Waterland, and the whole of the sections it is not rare, and is one of the group found in the purer limestone. Some of the specimens measure 8 inches in length, and 1½ inches in diameter across the thick end. A few of *Aviculopecten* are found in all the sections. *A. granosus*, Phill., and *A. fimbriatus*, Phill., are found in a shale band at Hillhead, also *A. flexuosus*, M'Coy. At one place the latter was rather abundant, while the former was rare. They are also found at Auchenskeoch, Cunningham-Baidland, Waterland, and Howrat. In this latter section *A. flexuosus*, M'Coy, and *Pecten Sowerbii*, M'Coy, are rather abundant in the old quarry north of the farm-house, along with others. Two species of *Axinus* are found in a shale at the base of the series at Waterland. *Edmondia quadrata*, M'Coy, is found in shale at Hillhead; *Conocardium aliforme*, Sow., occurs at Auchenmade near the top of the present section. A few more lamellibranchs are found, but on the whole the group is rare, and not well represented.

Gasteropoda.—This group is also poorly represented in the series. One specimen from Auchencloich, three from Cunningham-Baidland, and one from Trearne, are the whole that have come under my observation. They are certainly all but absent from this group of beds as far as I have noticed them.

Heteropoda.—This group is represented in all the sections by *Bellerophon cornu-arietis*, Sow, which is moderately plenty in all the sections, except Trearne, Hillhead, and Dockra, where they are very rare. This species, along with *B. decussatus*, Flem., and *B. Dumontii*, D. Orb., is found at Auchenskeoch, Howrat, and Waterland. At one time specimens were rather abundant in the former of these sections, as well as in the quarry south of Howrat farm-house; also at Waterland, and in the railway cuttings here, and at Bourock, but taken on the whole, the group is not a profuse one in the series.

Cephalopoda.—Although this group is present in all the sections, and pervades the series from top to bottom, the specimens are sparsely scattered, and the genera and species few. The more common are *Cyrtoceras rugosum*, Flem., *Nautilus ingens*, Mart., and an *Orthoceras*, very abundant in a shale at Hillhead and Howrat, but too much crushed to be satisfactorily identified. All that

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have been detected are given in my list. As far as I have noticed the group it is not a profuse one in the series.

Pisces.—This group of marine fauna is represented in the series by teeth and dermal shagreen tubercules. These remains are found in all the sections, and in the series from top to bottom, but not abundantly. The Beith sections have been the best observed, and here *Petalodus Hastingsiæ*, Owen, is most abundant, and is found chiefly in centres or groups, a number being found on the same horizon, and in a circle of 10 to 20 yards. This is the general character, although as a rule it has exceptions. *Cochliodus acutus*, Ag., *Tomodus convexus*, Ag., *Helodus didymus*, Ag., and *Petalorhynchus Benniei*, Etheridge, are the more common forms found. The large palates, *Psammodus rugosus*, Ag., and *P. porosus*, Ag., are very rare, few of them turning up, but this is owing more, perhaps, to a metamorphism of the organic matter into stone, than to a deficiency of living forms in the ancient Carboniferous sea. I have specimens that are all but metamorphosed, and I have seen specimens of which only the outline could be traced, the organism being changed into hard stone. This remark relates to other remains than teeth; it appears that soft animal matter, deposited in the calcareous mud of this series, has been invariably metamorphosed or replaced by limestone, more crystalline than elsewhere, and flecked with minute spots of a dull amber colour. In all the sections the same teeth occur, and appear to be distributed very similarly to what they are in the Beith ones. The series cannot be said to be rich as a deposit in fish remains, still a considerable number of specimens have been obtained.

This concludes the inferior beds of the series, and might be taken as a fair vidimus of the whole, but as slightly different physical characters occur in the superior beds, a short notice of them may be given.

Coral band.—A coralline band, chiefly made up of rugose corals is found at Trearne, Dockra, Cunningham-Baidland, and Gameshill. I have not found it at Howrat, but in all the others it has a partial appearance. It runs from a mere band of corals in the line of division, between two limestone beds, to a bed 2½ feet in thickness, entirely built up with crushed corals. It appears to be very rich in genera and species, but from their state of preservation identification of the specimens is difficult. A good deal has yet to be done in the explication of this band, but at present the following appear to be

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the more common forms. *Cyathophyllum regium*, Phill.; *C. Stutchburyi*, M. Edw.; *Campophyllum Murchisoni*, M. Edw.; *Clisiophyllum turbinatum*, M'Coy; *C. Bowerbanki*, Ed. and H.; *C. coniseptum*, M. Edw.; *Zaphrentis Bowerbanki*, M. Edw.; *Z. Phillipsi*, M. Edw.; *Z. cylindrica*, Scouler; *Koninckophyllum magnificum*, Thom. and Nich.; *K. interruptum*, Thom. and Nich. These are all moderately common, and others appear not less rare. While speaking of the corals, it may be here stated that *Alveolites septosa*, Flem., is found in the pure limestone at all the sections, and is moderately common, some very fine specimens being found at Trearne.

Superior beds.—Above the coral band lie 25 feet of limestone, when the beds are all on, but this depth is not uniform, owing to the irregularity of the beds of limestone. The sections where the full beds are found, are Waterland, Trearne, Dockra, Cunningham-Baidland, and Howrat, while in the others the superior beds are much reduced by denudation. At Trearne, the 6 feet limestone overlying the coral band is thin bedded, and contains a stray coral. At Waterland and Cunningham-Baidland are two bands full of *Lithodendron*, which are not present at Trearne. Above this, at the latter section, a three feet bed of white limestone occurs, very full of *Polyzoa;* at the former sections it is found reduced to a few inches, but still holding *Polyzoa*. Some of the Trearne species are new, and have been described by Dr Young and Mr John Young, F.G.S.

Above this bed, and resting upon it, at Trearne occurs a shale band varying from an inch to six inches, which is very rich in *Polyzoa*, the genera and species found in the limestone bed having been carried up into it. The principal genera are *Fenestella*, *Polypora*, *Glauconome*, *Rhabdomeson*, and *Sulcoretepora;* the two former being common, but in portions of the bed the others are not rare. Resting upon the shale is a bed of white limestone containing *Polyzoa*, but not so abundantly as in the bed below the shale, while in both beds the presence of *Polyzoa* is irregular, sometimes most plentiful, at others nearly absent. These beds of white limestone are found in most of the sections where they are not denuded off, although reduced in thickness, and wherever found they contain more *Polyzoa* than is common to the other beds of the series. Above the latter, at Trearne, and in the other Beith sections, lies a bluish-grey marled bed, wrought at one time

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for marble. It is freer of shell remains than the other beds, and fish teeth are very rare in it, being all but absent, while crinoid stems are abundant. Above it lies,—and capping the series in the Beith quarries, where the beds are on in full—a bed of white limestone, often 10 feet in thickness, very full of crinoids, brachiopods, and fish teeth, principally *Petalodus Hastingsiæ*, Owen; and *P. rectus*, Ag. A few other cochliodonts are also found, but are rare. This bed is absent at Cunningham-Baidland, Howrat, and Waterland. In the former of these it is interbedded with thin beds of *Lithostrotion*, and thin bands of intercalated shales, the latter rather rich in fish teeth, some of the species being rare, and, I believe, new to the locality, if not to science. In the two latter sections, the encrinital beds are represented by a bed of very fine limestone almost free from crinoids and other fossils. It has the appearance of a fresh-water limestone, but a marine shell found in it at intervals shows its origin. Howrat and Waterland are very similar, both in their physical and fossil aspects, and diverge considerably from the typical sections at Trearne. But whatever slight difference may be in the series, as seen in the sections, the limestone appears to be terminated by a thin layer of volcanic ash, found resting upon it wherever it is preserved by superior beds. At one time I was inclined to believe that the ash was the accompaniment of volcanic action which had brought the calcareous deposits to a close by an upheaval of the sea bottom, but from more extended and closer observation it appears that the change of level had taken place at an earlier date, and that the marine deposits had terminated, by the sea bottom having become a land surface covered with vegetation previous to the deposition of the ash. Wherever the upper surface of the limestone has been preserved, it is found thickly studded with the roots and rootlets of *Stigmaria*. Many of the roots are of large size, and are generally spread in the limestone about 15 inches below its surface, and are met with from this upward. Streaks of ash are found in it to this depth, but evidently as the result of percolation and filling up, when the roots decayed. The fossil evidence shows that this land, covered with a luxuriant forest of *Sigillaria*, had again become sea bottom when the ash was deposited. In the marine limestones, the remains of *Megalichthys* and *Platysomus* are never found, but a thin stratum above the coal at the base of the series, and another

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above the coal in the divisional shales, are very rich in these remains. Both of these fish beds form the commencement of estuarine strata upon old land surfaces, and in a thin stratum below this ash the remains of these fishes reappear, just as they do in the strata above the two beds of coal. This evidence entitles the inference that the land with its primitive forest had sunk into an estuarine bottom, followed afterwards by an influx of marine life, which the ash has destroyed, the remains being in a very comminuted state. The stratum that holds them is much indurated and partially crystallised, a state of metamorphism common in the limestone where the calcareous deposit has been mixed with animal matter. Fish teeth are found in the ash near its base, but it requires farther observation to see whether they extend throughout its whole thickness.

In conclusion, I have to tender my thanks to Mr John Young, F.G.S., for his assistance in aiding me to identify the fossils found in the limestone, a kindness extended over a number of years. To him I am entirely indebted for naming the genera and species of both the *Polyzoa* and *Entomostraca* in the annexed list. I have also pleasure in mentioning Mr James Armstrong, who has been always ready to impart his palæontological knowledge when I met him in the field. I have to thank Mr James Thomson, F.G.S., for copies of his papers on the "Carboniferous Corals," which have enabled me to add a few new names to this group.

In the annexed list I have confined the inferior and superior beds, as wrought in the sections, to one column, with the exception of Waterland and Trearne. At Cunningham-Baidland and Howrat very little of the inferior beds is worked, and in the other sections, except a small area at Dockra, the superior beds are much reduced by denudation. The sub-series of this limestone is divided into four parts, differing slightly both physically and palæontographically (see Transactions of the Society, Vol. V., page 36), but in the beds under notice there is much similarity in the fossil aspects throughout. Nests occur where more of the rarer forms may be preserved than is generally the case, and in these a form new to the series may occur, but such are not confined to any particular part of the series, but are common to the whole. The list may therefore be taken as giving, on the whole, the fossils of both the inferior and the superior beds.

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FOSSILS FOUND IN THE UPPER SERIES OF THE LOWER CARBONIFEROUS LIMESTONE.

Species.	Waterland.		Trearne.			Dockra.		Hillhead of Broadstone.		Cunningham-Baidland.		Auchenskeoch.	Auchenmade.	Howrat.
	Inferior Beds.	Superior Beds.	Inferior Beds.	Coral Band.	Superior Beds.	Coral Band.	Inferior Beds.	Inferior Beds.	Coral Band.	Coral Band.	Superior Beds.	Inferior Beds.	Inferior Beds.	Superior Beds.
PROTOZOA (SPONGIDÆ).														
Haplistion Armstrongii, Young and Young.										×				
Hyalonema Smithii, Y. and Y.	×	×	×		×		×	×			×	×	×	×
ACTINOZOA.														
Alveolites depressa, Fleming.		×	×		×		×	×		×	×	×		
„ *septosa*, Flem.	×	×	×		×		×	×		×	×	×	×	×
Amplexus coralloides, Sowerby.				×	×	×			×	×		×		×
„ *cornu-bovis*, Sow.				×		×			×	×				
„ *Henslowi*, Milne Edwards.				×		×			×	×				
„ *nodulosus*, Phillips.									×					
Aspidophyllum cruciforme, Thomson.				×		×			×	×				
Campophyllum Murchisoni, M. Edw.		×		×		×			×	×	×	×		×
Cladochonus Michelini, M. Edw.										×		×		
Clisiophyllum bipartitum, M'Coy.				×		×				×		×		
„ *Bowerbankii*, E. and H.		×		×	×	×				×	×	×		×
„ *coniseptum*, M. Edw.				×		×		×		×		×		×
„ *turbinatum*, M'Coy.	×	×		×				×	×	×		×		×
Cyathophyllum regium, Phill.				×		×			×	×		×		
„ *giganteum*, Michelin.				×	×	×			×			×		
„ *expansum*, M'Coy.				×		×			×			×		
„ *Stutchburyi*, M. Edw.	×			×		×			×	×		×		
„ *paracida*, M'Coy.		×			×		×				×	×		×
Cyathaxonia Konincki, E. and H.										×				
Fistulipora minor, M'Coy.					×									
Heterophyllia angulata, Duncan.		×	×		×		×	×			×	×	×	×
„ *mirabilis*, Dunc.										×				
Koninckophyllum interruptum, Thomson and Nicholson.		×		×		×				×				
Lophophyllum eruca, M'Coy.				×					×	×		×		

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Species.	Waterland.		Trearne.			Dockra.		Hillhead of Broadstone.		Cunningham-Baidland.		Auchenskeoch.	Auchenmade.	Howrat.
	Inferior Beds.	Superior Beds.	Inferior Beds.	Coral Band.	Superior Beds.	Coral Band.	Inferior Beds.	Inferior Beds.	Coral Band.	Coral Band.	Superior Beds.	Inferior Beds.	Inferior Beds.	Superior Beds.
Actinozoa—*Continued.*														
Lithostrotion basaltiforme, Flem.	×				×		×					×		×
„ *Portlocki*, M. Edw.			×							×				
Lithodendron irregulare, Phill.	×	×	×		×		×	×			×	×	×	×
„ *junceum*, Flem.		×	×				×				×	×	×	×
Stenopora tumida, Phill.	×		×		×		×	×			×	×	×	×
Zaphrentis Bowerbankii, M. Edw.	×			×	×	×				×	×	×		
„ *Griffithi*, M. Edw.				×					×	×		×		
„ *Phillipsi*, M. Edw.				×		×			×	×		×		
„ *cylindrica*, Scouler.				×		×		×			×	×		
Echinodermata (Echinoidea).														
Archæocidaris Urei, Flem.		×			×		×	×		×		×		×
„ *Münsteriana*, De Koninck.		×			×		×	×		×				
Melonites Youngii, Keeping, (M.S.)	×				×									
Echinodermata (Crinoidea).														
Platycrinus lævis, Miller.	×	×	×		×		×	×			×	×	×	×
Poteriocrinus calyx, M'Coy.	×	×	×		×		×	×			×	×	×	×
„ *crassus*, Mil.	×	×	×		×		×	×			×	×	×	×
„ *Maccoyanus*, De Kon.	×	×	×		×		×	×			×	×	×	×
„ *nuciformis*, M'Coy.				×										
„ *quinquangularis*, Mil.	×		×				×	×			×	×	×	×
Rhodocrinus uniarticulatus, De Kon.	×	×	×		×		×	×			×	×	×	×
Annelida.														
Ortonia carbonaria, J. Young.								×						
Serpulites carbonarius, M'Coy.	×	×	×	×	×		×	×			×	×	×	×
„ *membranaceus*, M'Coy.	×		×				×	×			×	×	×	×
Spirorbis Archimedes, De Kon.			×		×		×	×						
Vermilia minuta, Brown.			×											
Crustacea (Trilobita).														
Griffithides Eichwaldi, Fischer.	×													×
„ *mesotuberculatus*, M'Coy.	×	×	×		×		×	×			×	×	×	×

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Species.	Waterland.		Trearne.			Dockra.		Hillhead of Broadstone.		Cunningham-Baldland.		Auchenskeoch.	Auchenmade.	Howrat.
	Inferior Beds.	Superior Beds.	Inferior Beds.	Coral Band.	Superior Beds.	Coral Band.	Inferior Beds.	Inferior Beds.	Coral Band.	Coral Band.	Superior Beds.	Inferior Beds.	Inferior Beds.	Superior Beds.
Crustacea (Ostracoda).														
Bairdia ampla, Reuss.			×											
„ *curta* var. *plebeia*, J. and K.			×											
„ *subcylindrica*, Münst.			×											
Cytherella inflata, Münst.						×								
Cypridina brevimentum, J. and K.			×											
„ *primæva*, M'Coy.			×											
„ *oblonga*, J. and K.			×											
Cyprella chrysalidea, De Kon.			×											
Cypridella Edwardsiana, De Kon.			×											
„ var. *septentrionalis*, J. and K.			×											
„ *Koninckiana*, J. and K.			×											
Cypridinella Cummingii, J. and K.			×											
„ *superciliosa*, J. and K.		×	×				×	×			×			
Kirkbya Permiana, Jones.			×											
„ *umbonata*, D'Eichw.			×											
Leperditia Okeni, Münst.			×											
„ *Armstrongiana*, J. and K.			×											
Entomoconchus Scouleri, M'Coy.			×											
„ *globosus*, J. and K.			×											
Polycope Burrovii, J. and K.			×											
Crustacea (Phyllopoda).														
Cyclus radialis, Phill.			×											
„ *sp. nov.*			×											
Polyzoa.														
Actinostoma fenestratum, Y. and Y.			×											
Carinella cellulifera, Etheridge, jun.								×						
Diastopora megastoma, M'Coy.		×	×		×			×				×		×
Fenestella multiporata, M'Coy.														
„ *plebeia*, M'Coy.	×		×		×		×	×			×	×	×	×
Glauconome bipinnata, Phill.	×		×		×		×	×			×	×	×	×
„ *flexicarinata*, Y. and Y.			×									×		
„ *robusta*, Y. and Y.												×		
„ *retroflexa*, Y. and Y.					×									
Polypora dendroides, M'Coy.	×		×		×		×	×			×	×	×	×
„ *tuberculata*, Prout.	×				×			×				×		×
Rhabdomeson gracile, Phill.			×		×							×		
„ *rhombiferum*, Phill.			×											

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Species.	Waterland.		Trearne.			Dockra.		Hillhead of Broadstone.		Cunningham-Baidland.		Auchenskeoch.	Auchenmade.	Howrat.
	Inferior Beds.	Superior Beds.	Inferior Beds.	Coral Band.	Superior Beds.	Coral Band.	Inferior Beds.	Inferior Beds.	Coral Band.	Coral Band.	Superior Beds.	Inferior Beds.	Inferior Beds.	Superior Beds.
POLYZOA—*Continued.*														
Sulcoretepora parallela, Phill.					×							×		×
„ *Robertsoni*, Y. and Y.					×									
BRACHIOPODA.														
Athyris ambigua, Sow.	×				×		×	×			×	×		×
„ *lamellosa*, Léveille.			×											
„ *plano-sulcata*, Phill.	×	×	×		×		×	×			×	×	×	×
„ *Royssii*, Lév.					×		×							
Camarophoria globulina, Phill.												×		
Chonetes Laguessiana, De Kon.	×	×	×		×		×	×			×	×	×	
Crania quadrata, M'Coy.			×					×						
Discina Craigii, Dav.					×		×							
„ *nitida*, Phill.	×							×				×		×
Orthis Michelini, Lév.	×		×				×	×			×	×	×	×
„ *resupinata*, Martin.	×		×		×		×	×			×	×	×	×
Productus aculeatus, Mart.		×	×		×		×	×			×	×	×	×
„ *cora*, D'Orbigny.	×		×		×		×	×			×	×	×	×
„ *costatus*, J. de C. Sowerby.	×	×	×		×		×	×			×	×	×	×
var. *muricatus* Phill.					×		×	×			×		×	×
„ *fimbriatus*, J. de C. Sow.	×	×	×		×		×	×			×	×	×	×
„ *giganteus*, Mart.	×	×	×		×		×	×			×	×	×	×
„ *latissimus*, J. de C. Sow.		×	×		×			×			×			×
„ *longispinus*, Sow.	×	×	×	×	×			×			×	×	×	×
var. *lobatus*, Sow.								×			×			×
var. *setosa*, Phill.	×	×	×	×	×			×	×	×	×	×	×	×
var. *spinosus*, Sow.	×	×	×	×	×	×		×	×		×	×	×	×
„ *mesolobus*, Sow.			×					×						×
„ *punctatus*, Mart.	×	×	×		×		×	×	×			×	×	×
var. *elegans*, M'Coy.	×	×	×		×		×	×			×	×	×	×
„ *scabriculus*, Mart.	×	×	×		×		×	×			×	×	×	×
„ *semireticulatus*, Mart.	×		×		×		×	×			×	×	×	×
var. *Martini*, Sow.	×	×	×		×		×	×			×	×	×	×
var. *concinnus*, Sow.			×		×		×	×			×			
var. *sulcatus*, Sow.	×	×	×		×		×	×			×	×	×	×
„ *spinulosus*, Sow.	×	×	×		×		×	×			×	×	×	×
„ *Youngianus*, Dav.	×	×	×		×		×	×			×	×	×	×
Rhynchonella pleurodon, Phill.		×	×		×		×	×			×	×	×	×
„ *pugnus*, Mart.		×	×		×		×	×			×	×	×	×

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Species.	Waterland.		Trearne.			Dockra.		Hillhead of Broadstone.		Cunningham-Baidland.		Auchenskeoch.	Auchenmade.	Howrat.
	Inferior Beds.	Superior Beds.	Inferior Beds.	Coral Band.	Superior Beds.	Coral Band.	Inferior Beds.	Inferior Beds.	Coral Band.	Coral Band.	Superior Beds.	Inferior Beds.	Inferior Beds.	Superior Beds.
BRACHIOPODA—*Continued.*														
Spirifera Carlukensis, Dav.							×	×						
„ *duplicicosta*, Phill.	×	×	×		×		×	×			×	×		×
„ *glabra*, Mart.	×	×	×	×	×		×	×			×	×	×	×
„ *lineata*, Mart.	×	×	×		×		×	×			×	×	×	×
„ *ovalis*, Phill.			×		×		×	×			×		×	
„ *pinguis*, Sow.		×	×		×			×					×	
„ *trigonalis*, Mart.	×	×	×		×			×			×	×	×	×
var. *bisulcata*, Sow.	×	×	×		×		×	×			×	×	×	×
„ *triradialis*, Phill.			×				×							
„ *Urei*, Flem.							×							
Spiriferina cristata.														
var. *octoplicata*, Sow.		×	×				×	×			×	×		
„ *laminosa*, M'Coy.												×		
Streptorhynchus crenistria, Phill.	×	×	×		×		×	×			×	×	×	×
var. *radialis*, Phill.								×						
var. *robusta*, Hall.	×	×	×		×		×	×			×	×	×	×
Strophomena rhomboidalis, var. *analoga*, Phill.								×						
Terebratula hastata, Sow.	×	×	×		×		×	×			×	×	×	×
var. *Gillingensis*, Dav.										×				
var. *sacculus*, Mart.	×	×	×		×		×	×			×	×	×	×
LAMELLIBRANCHIATA (MONOMYARIA)														
Avicula lævigata, M'Coy.			×					×						×
Aviculopecten concentricostriatus, M'Coy.			×				×							
„ *consimilis*, M'Coy.			×											
„ *fimbriatus*, Phill.	×		×								×	×		×
„ *flexuosus*, M'Coy.			×				×	×						
„ *granosus*, Phill.	×				×			×						×
„ *incrassatus*, M'Coy.												×		
„ *imbricata*, M'Coy.			×											
„ *Haidingerianus*, De Kon. ?			×				×							
„ *Knockonniensis*, M'Coy.?			×											×
„ *Leaji*, De Kon.			×											
„ *serratus*, M'Coy.														×
„ *sp. nov.*			×											

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Species.	Waterland.		Trearne.			Dockra.		Hillhead of Broadstone.		Cunningham-Baidland.		Auchenskeoch.	Auchenmade.	Howrat.
	Inferior Beds.	Superior Beds.	Inferior Beds.	Coral Band.	Superior Beds.	Coral Band.	Inferior Beds.	Inferior Beds.	Coral Band.	Coral Band.	Superior Beds.	Inferior Beds.	Inferior Beds.	Superior Beds.
Lamellibranchiata (Monomyaria)—*Continued.*														
Pecten Sowerbii, M'Coy.			×					×						×
Pinna flabelliformis, Mart.	×	×	×		×		×	×			×	×	×	×
„ *flexicosta*, M'Coy. ?														×
Lamellibranchiata (Dimyaria).														
Axinus carbonarius, Portlock.	×		×											×
„ *sulcatus*, Sow.	×													
Cardiomorpha lamellosa, De Kon.	×													
Conocardium aliforme, Sow.			×										×	
„ *armatum*, Phill.					×								×	
Edmondia quadrata, M'Coy.			×					×					×	
Modiola lingualis, Phill.			×											
Nucula gibbosa, Flem.					×			×						
Gasterofoda.														
Eulima Phillipsiana, De Kon.	×		×					×			×			
Euomphalus pentangulatus, Sow. ?	×	×	×					×			×			×
Macrocheilus acutus, Sow.	×							×						
Murchisonia quadricarinata, M'Coy					×			×						
Naticopsis canaliculata, M'Coy.			×					×						×
Pleuotomaria Yvanii, Lév.			×								×			
Platyceras, sp. ?					×						×			
Turbo biserialis, Phill.											×			
Heteropoda.														
Bellerophon cornu-arietis, Sow.	×	×	×		×		×	×			×	×	×	×
„ *decussatus*, Flem.	×	×									×	×		×
„ *Dumontii*, De Orb.	×	×	×								×	×		×
Cephalopoda.														
Cyrtoceras rugosum, Flem.	×						×	×						×
Nautilus globatus, Sow.	×	×						×						
„ *ingens*, Mart.		×			×		×	×			×	×	×	×
„ *Léveillianus*, De Kon.	×		×											

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Species.	Waterland.		Trearne.			Dockra.		Hillhead of Broadstone.		Cunningham-Baidland.		Auchenskeoch.	Auchenmade.	Howrat.
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CEPHALOPODA—*Continued.*														
Orthoceras cinctum, Sow.	×						×	×			×	×	×	×
„ *attenuatum*, Flem.		×	×					×						×
„ *undatum*, Flem.					×			×			×	×		×
PISCES.														
Asteroptychius ornatus, M'Coy.					×									
Chomatodus truncatus, M'Coy.					×									
Cladodus mirabilis, Ag.		×	×		×		×	×			×	×		×
„ *striatus*, Ag.		×	×		×			×			×	×		×
Cochliodus compactus, Owen.	×	×	×		×			×			×	×		×
„ *contortus*, Ag.		×	×		×		×	×			×	×		×
Ctenoptychius serratus, Ag.	×	×	×		×		×	×			×	×	×	×
„ *sp. nov.*					×			×				×		
„ *sp.* ?					×			×				×		
Deltoptychius acutus, Ag.		×			×			×			×	×		×
Erismacanthus Jonesii, M'Coy.					×									
Helodus didymus, Ag.	×	×	×		×		×	×			×	×	×	×
„ *mammilaris*, Ag.					×			×			×	×		
„ *lævissimus*, Ag.		×	×		×		×	×			×	×	×	×
Homocanthus macrodus, Ag.					×						×			
Orodus, sp. ?								×			×			
Petalodus Hastingsiæ, Owen.	×	×	×		×		×	×			×	×	×	×
Petalorhynchus psittacinus, Ag.			×		×			×			×	×		×
„ *Benniei*, Eth.		×	×		×		×	×			×	×	×	×
Pœcilodus aliformis, Ag.					×							×		
„ *obliquus*, Ag.			×		×			×			×	×		×
Polyrhizodus radicans, Ag. ?					×							×		
„ *pusillus*, Ag.												×		
Psammodus rugosus, Ag.		×	×		×		×	×			×	×		×
„ *porosus*, Ag.					×		×	×			×	×		×
Psephodus magnus, Ag.		×	×		×		×	×			×	×		×
Tomodus convexus, Ag.	×	×	×		×		×	×			×	×	×	×
Xystrodus striatus, Ag.					×			×			×	×		×

NOTE.—In the Auchenmade column it will be noticed that a deficiency of crosses exists when compared with the others. This is owing to a want of examination, the beds there being as fossiliferous as the others, but not wrought to the same extent.

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II.—*Description of a* Dry River Bed *in the* Desert of Atacama, North Chile. By Thomas King.

[Read 1st February, 1877.]

Chile is a long narrow strip of land lying between the summits of the Andes and the Pacific Ocean. It extends from the tropic of Capricorn to Cape Horn, or from 24 deg. to 56 deg. south latitude —a distance of 2000 miles, while its average breadth is under 100 miles. Its length, therefore, exceeds its breadth about 20 times. In a tract of country extending over 32 degrees of latitude in the temperate zone we may expect to find great diversity of climate. North Chile is a sandy desert, South Chile is a rainy forest; in the former cotton grows to perfection, in the latter glaciers descend even to the sea. The central provinces enjoy a climate resembling that of Italy; from the spring to the autumn equinox no rain falls, while the rest of the year is rainy. In South Chile there are innumerable rivers and lesser streams, but, as we go northwards, the country gets drier, the streams fewer and smaller, until at last we reach a region in the north where the river beds have no water in them. The one I intend to speak of to-night is at Carrizal, in the province of Atacama, 28 deg. south latitude, or 300 miles north of Valparaiso. One cannot say exactly where the desert begins. The last considerable river north of Valparaiso is the Aconcagua, beyond it being a few smaller ones, but all the country north of Coquimbo may be called desert. From this point to the north limit of Chile is a distance of 360 geographical miles. The surface continues much the same through Bolivia, so that the desert of Atacama is at least 500 miles in length. No one would live in this region were it not for the mineral wealth it contains, and also that here and there at long intervals there are fertile spots on the banks of small streams which come down from the Andes.

The following will illustrate the small value of land in this district. There being no well-defined boundary between Chile and Bolivia, the two Governments named a Commission to fix one. They went to the parallel of lat. 24 deg., and there erected a pillar on which was placed this inscription—"All the territory to the north of this pillar belongs to Bolivia." Then going south

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to the parallel of lat. 25 deg., they raised another pillar on which was inscribed—"All the territory to the south of this pillar belongs to Chile;" thus leaving between the two boundaries a strip of land 60 miles in breadth belonging to neither country—a "No man's land." But when I was in the country rich veins of silver were discovered in this very strip, and then there arose a talk of war, for both claimed the mines. The matter was, however, amicably adjusted, and the mines are now being worked, specimens from them being on the table. They are known as the mines of Caracoles, from the fossils which are found in the rocks there, *caracol* being Spanish for shell.

I do not know the average annual rainfall in the south of Chile, but at Valparaiso, on the coast, it is 17 inches; at Santiago, inland, 13 inches; and at Carrizal Bajo, perhaps 1 inch. This last is a guess, but there are only about two showers in the year, sometimes not one; and since I came home there has been no rain for two years in succession. The surface in the Carrizal district consists of sand and gravel and bare rock. There is naturally little vegetation, but after a good shower, seeds, bulbs, and tubers, which have been lying dormant, waken up and clothe the desert with beauty. There are also some shrubs which in spite of a two years' drought are not killed, even though they become so much affected as to lose their leaves. Still farther north the rainfall is so trifling that at Copiapo the houses are roofed with mud, which becomes very hard from the heat of the sun. Shortly before I visited that town there had been rain, and there had been much annoyance from leaking roofs.

I now come to the more immediate subject of my paper, but it was necessary that I should give these explanatory notes about the country to render my remarks intelligible. In going from Valparaiso to Carrizal to visit my brother, who had lately been appointed Superintendent of the railway there, I found his house and the railway station situated in the mouth of a flat valley where it opened to the sea, and only a few feet above its level. I did not understand the geological structure of the district. Soon after arriving I walked inland along the bottom of the valley, which was dry, and the railway sleepers were laid on the gravelly surface. At the distance of a mile from the sea it might be 200 yards wide, with banks 100 feet high. On clambering up these I found them composed of gravel, sand, and clay containing many sea shells,

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which were apparently of such species as are now living in the neighbouring seas. The effect of the previous winter's rain was clearly to be seen. There had not been, perhaps, altogether ten hours' rain, but the soft sand was cut into little ridges and furrows. On rising from the valley I found a view never to be forgotten. I was standing on a small plain reaching from the base of the hills to the sea, and on the other side of the valley was a corresponding plain. The two had formerly been one, but a stream had evidently dug out the valley. I was, in fact, on an old terrace which had at one time formed the sea bottom. The shore had been at the foot of the present line of hills up to which the waves had raced as they do now on the existing beach. They had left behind the sand which the wind, setting steadily from the south, had drifted into long tongues up the faces of the hills, and is, in some places at least, still bearing forward. Returning down the valley, I found in its midst an old island about 30 feet in height, and composed of the same materials as the banks. On it I obtained some fine fossil Pectens.

The question naturally arose—What had become of the water which dug out the valley? At first I adopted the generally received opinion that the water had disappeared in consequence of the destruction of vegetation by man. It is certain that there were trees in this district in former times (though there are none now), for some people make it their business to dig out their roots for firewood, and these form a considerable article of traffic on the railway. It is well known that the Spaniards, by every means in their power, encouraged the search for metals. If a man discovered a vein of silver, no matter in whose ground, the mine was his. He also had the right to cut wood to smelt the ore, and so in course of time the surface was bared of its trees. But in opposition to this theory there occurred to me the well-known historical fact that the desert of Atacama existed before the Spanish invasion. The Spaniards first conquered Peru, and from that country conquered Chile; but the invading army came down the east side of the Andes, crossing the chain at a pass 13,000 feet above the sea, rather than risk a journey through the terrible desert. A very intelligent gentleman, who had long lived in the district, suggested that this valley is not a river bed at all, but simply a channel cut out by the sea as the country slowly rose above its level. This is disproved by one simple fact—the main channel has smaller tributary beds

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opening into it. Another suggestion I have heard or read, is that the chain of the Andes may have risen to some extent, and so more completely shut out the moist winds coming from the Atlantic ocean. I have no doubt the Andes have risen and are rising, as the whole coast seems to be doing. But this valley must have been hollowed out as it now exists since the land reached its present level. The railway begins 6 feet above the sea, and beside the station, in a lower part of the valley, is a lagoon a quarter of a mile long, into which the sea flows at every tide. The railway starting from Carrizal Bajo runs 62 miles inland, *i.e.*, measuring along the line. There is on it neither cutting nor banking, tunnelling, bridging, nor fencing (with the exception of here and there levelling a few feet of superficial gravel), the gradient for the entire distance being about 1 per cent. An incident occurred when I was there which shows the undisturbed slope of the valley traversed by the line. Mr. Thomas, superintendent of the mines of Cerro Blanco, got his thumb badly hurt one evening with gunpowder. He went to the railway terminus at Yerba Buena to get an express to go to the port to the doctor. There was no locomotive there that night, but one of the railway servants got a small truck and he and Mr. Thomas allowed themselves to run down the incline of 60 miles. They reached the port in the morning, and the doctor dressed the thumb. I said before that the annual rainfall of the district is about 1 inch, but it is sometimes nothing at all. However, there is occasionally a flood.

I have given above three theories put forward to account for the formation of this dry river bed, but not one of them is satisfactory. I will now give what I believe to be the true explanation. In 1872, while I was still in Chile, part of the railway was washed away, and an engine ran into the water and there stuck. There is a tradition, too, that a man and his horse had to wait at the side of the river till it got low enough for them to cross. I believe that to be just another older "spate" than the one of 1872. Probably when there were trees the rainfall might be somewhat greater than now. Water might run in the valley a few days every year, and that, with an occasional flood, would at length wear out the channel as we find it. But the length of time necessary to bring about such a result is oppressive to think of. My explanation, then, is that the valley or river bed has

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been hollowed out chiefly by occasional spates. I do not think that there was ever a river in the valley except for a few days at a time, and while I grant that the destruction of the few trees and bushes that once grew there may have slightly diminished the rainfall of the district, yet I hold that it has been a desert ever since it rose above the waves of the Pacific.

Two miles beyond the Carrizal Bajo terminus the railway goes in amongst the hills, and turns about with the windings of the valley, the way, as it were, ever opening up before and closing from behind. The hills here are perhaps 2000 feet high; not rugged or picturesque, but rather rounded and common-place. The rock is, I think, chiefly gneiss. The first time I went up in the train through this district, I made a curious mistake regarding the structure of a hill we were approaching. I saw lines of stratification across its face dipping at a high angle towards the south. But on looking more closely I found they were but the shadows cast by the bare stems of the cactus. At the second station, Canto del Agua, one branch of the railway leaves the valley and goes up to the copper mines of Carrizal Alto. The other runs along the valley eastwards, and enters, about twenty-four miles inland, a wide plain which it crosses in a straight line 15 miles in length. The track then enters a mountainous region, winding about, as in the former instance, till it reaches Yerba Buena. The ascent here being too heavy for locomotives, the railway comes to an end, though the copper mines of Cerro Blanco are 8 miles farther on. As a rule, the country along this route is dry, sandy, stony, and bare. But, the summer after the flood I have mentioned, the ground was entirely covered with vegetation. At a mile's distance could be seen the dark purple of the flowers which clothed the hillsides.

The question may already have occurred to you, Where is water for man and beast to be got in this dry desert? Well, at the Canto del Agua Junction already spoken of, the valley gets soft and slushy in the winter time, and there, where the grass grew, the people dug pits, which soon filled with beautiful clear water. It was, however, to my taste perfectly undrinkable, being salt and bitter. As my brother found it to be very unsuitable both for human beings and for steam engines, he sent some bottles of it to a chemist in Valparaiso to see if he could suggest any method of removing the contained salts—

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of three or four kinds—but with no success. On more carefully examining the structure of the valley, my brother discovered that the surface, at the place I described as getting soft in winter, was composed of a layer of salts from 2 to 3 feet thick. He thought that fresh water might probably be found below this layer, and that, if a well could be sunk down through it and carefully puddled, there was a prospect of finding a supply of good water, and the directors of the railway gave him leave to spend 500 dollars on the experiment. Accordingly, he chose a spot, 2 miles above the junction, where a sloping hill of compact rock formed one side of the valley. First 3 to 4 feet of white salts were cut through, and then blue clay was found. The workmen boarded the sides neatly with cypress boards, puddling firmly between them and the sides of the well. On reaching a depth of 38 feet, water was struck, and it rushed in with such force that the man at the bottom sang out to be hauled up, as he was in danger of being drowned. It rose to within a few feet of the top and was comparatively good water, though not quite free from salts. A pipe was laid from the well down to the junction, whence, by means of tanks upon trucks, it is distributed along the railway. I calculated that it supplied about 8000 human beings, besides animals and locomotives.

III.—*On the* Presence *of* Hermit Crabs *in the* Post-tertiary Clays *of the* Clyde Basin. By David Robertson, F.L.S., F.G.S.

[Read 12th April, 1877.]

The Hermit Crab (tribe Anomoura, family Paguridæ) is common in the estuary of the Clyde, both in deep and in shallow water, and is abundantly seen scrambling amongst the stones, carrying upon its back its house, consisting of a disused shell. It does not appear to be partial to any particular species of shell, provided that the accommodation is found suitable. The occupation of the house can only be temporary, as increasing growth will necessitate a bigger tenement from time to time. The young of the larger species are first met with inhabiting very small turbinated shells of various species, until they gradually reach those of the large *Buccinum*, which seem to meet their utmost requirements, and

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wherein they can settle down for life, free from the annoyances of further removals. The anterior legs and claws of this family are the only portions which are hard or calcareous, the other parts being soft or chitonous, and protected by the borrowed shell. A shell which has been occupied, particularly by one of the larger crabs, can be readily distinguished by the rubbed and polished appearance of the right side, owing to its having been drawn by the inmate over the sand and gravel of the sea bottom. The claws of Hermit Crabs are common in our Post-tertiary Clays, and occasionally the shells they have occupied. I am not quite sure, however, that these claws belong to any of the species inhabiting our present seas.

Be this as it may, what I wish chiefly to call attention to is the important fact that not a single carapace of any of the other crabs *(Brachyura)*, and which swarm in our seas, has been met with, so far as I know, in our Post-tertiary Clays. We may reasonably assume that the carapaces of those large crabs, including the larger species of the *Macroura* family (the common and Norwegian lobsters), are as hard and indestructible as the claws of any of the Hermit Crabs; and we are therefore forced to the inference that the latter were moderately common, while all the other crabs were rare, if not altogether absent from our seas during the deposition of the Post-tertiary Clays. This is all the more remarkable when we remember that the *Brachyura*, closely allied to those now living in the British seas, are common in the upper, middle, and lower divisions of the Tertiary formation, whilst many representatives of the same tribe are met with in the Cretaceous and Oolitic periods. It is further remarkable that we have no trace of the "Hermit" family further back than the Post-tertiary deposits. This may, however, be accounted for by the fact that only the forearms and claws of Hermit Crabs are hard enough to survive their long entombment in the clay; and these claws without being accompanied by the characteristically worn shell—the Hermit's old abode—might readily be mistaken as belonging to members of the *Brachyura* tribe, which is abundantly represented as far back as Carboniferous times.

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IV.—Notes *on* Crinoids *from* Inverteil, Fifeshire. By Arthur Pratt.

[Read 7th December, 1876.]

The specimens now laid on the table are the product of two holiday excursions to a locality not much known to Glasgow geologists, but endeared to me by recollections of boyhood. There, along with my father, I used to search all the quarries round about for "curiosities;" and Inverteil lime-quarry was one of our favourite spots for picking up what we called "stone shells" "horns," and "spar." On my first excursion, which was at the Glasgow Fair time of 1875, there had been no working at the quarries for nearly thirty years. Still, in the old shale heaps, although almost covered with grass and vegetation, I got some beautiful specimens of crinoid heads, which had doubtless lain all that time. When our respected friend, Mr. Bennie, now of the Geological Survey of Scotland, was in Glasgow at the late meeting of the British Association, he told me that the workings were resumed, so I gladly availed myself of an early opportunity of paying the neighbourhood another visit, which happened to be when Glasgow was keeping holiday in honour of the Prince and Princess of Wales. I then set off to the diggings, and am glad to say I had no cause to regret going, although on that day east coast weather was no better than that in the west, for I was at work under my umbrella more than three hours. Indeed, the rain did me some service, for it washed the surface of the recently put-out shale, and showed the contained organisms most beautifully. I discovered altogether the heads of five or six various species of crinoids, and stems and arms of about a dozen different species. The heads were all found in the shale, where their stems were also met with, but so far as I could see there were no heads in the limestone, which seemed to be almost literally made up of stems. It looked as if some sudden influx of muddy fresh water had killed them all instantaneously, for in the case of these, as in that of many other marine animals, fresh water acts as a strong poison, and their heads, dropping away from the stalks, had been swept off to some other spot. Several beds of this encrinital limestone

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alternate with layers of shale of various thicknesses, and I think that the reason of so many different species being found in the shale heaps may be accounted for by the fact that all the shale beds have been thrown together in the working—so that the species proper to each have got mixed. Amongst the species that I have been able to identify are examples of *Poteriocrinus nuciformis*, M'Coy; *P. calyx*, M'Coy; *P. Maccoyanus*, De Koninck; *P. crassus*, Miller; *Cyathocrinus planus*, Miller; *Platycrinus*, species; also numerous stems referable to the above genera as well as to that of *Actinocrinus*. Besides the crinoids, I found several species of corals, and specimens of *Euomphalus*, *Pleurotomaria*, *Petalodus Hastingsiæ*, etc. Indeed, all the beds are rich in organic life. Under the encrinital beds lies the *Productus* limestone, from 15 to 16 feet thick, containing in plenty *Productus giganteus*, *P. semireticulatus*, etc., but good examples are very difficult to get out.

[ABSTRACT.]

V.—REMARKS *upon* Prof. HULL'S PROPOSED TRIPLE DIVISION *of the* CARBONIFEROUS STRATA, *as contained in a paper entitled* "ON *the* UPPER LIMIT *of the* ESSENTIALLY MARINE BEDS *of the* CARBONIFEROUS SYSTEM *in the* BRITISH ISLES, *and the necessity for the establishment of a* MIDDLE CARBONIFEROUS GROUP," *which he* READ BEFORE SECTION C. *of the* BRITISH ASSOCIATION, GLASGOW, 1876. By JOHN YOUNG, F.G.S., V.P.

[Read 7th December, 1876.]

MR. YOUNG stated that there were few geologists in Britain entitled to speak with more authority upon the strata of the Carboniferous system than Prof. Hull, who had long studied the relations of the strata in the coal-fields of Scotland, England, and Ireland, in connection with his work on the Geological Survey. His proposed plan is to have the system grouped into seven successive stages in an ascending series, marked A to G. These seven stages he would further group into three chief divisions—A B representing the Lower Carboniferous slates, grits, and conglomerates, and the Lower division of the Carboniferous limestone; C D E taking the Yordale beds, Millstone Grit, and Ganister

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beds, which form the lower division of the Upper Coal measure; F G representing the Middle and Upper Coal measures. Prof. Hull proposes this classification chiefly upon palæontological grounds. A and B contain fresh-water and estuarine organisms, which alternate with marine forms in the lower stage; marine organisms being chiefly found in the upper one. C D E are essentially a marine series of deposits, as characterised by their contained fossils. F and G are fresh-water and estuarine. This embraces the chief points of Professor Hull's triple classification, he reserving for future detail the forms that characterise each division.*

Mr. Young remarked that the reading of Professor Hull's paper excited some discussion amongst the geologists present, most of them contending that there was no need for the proposed classification, especially as it is often impossible, from the character of the organisms, to draw hard and fast lines between the several divisions of the Carboniferous strata in Britain. He himself thought that a palæontological basis of classification such as Prof. Hull proposed would be preferable to one established principally on the lithological character of the strata. He saw, however, great difficulty in framing such a palæontological classification as would agree with the character of the organisms found in the various British coal-fields. The physical conditions, under which the strata of the same period in these coal-fields were deposited, varied very much in the different countries, and these conditions regulated the kind of life that prevailed over the land and over the lakes and sea bottoms. For example, the conditions under which the Carboniferous limestone series in Scotland was laid down were very dissimilar to those which prevailed over the coal-fields of England and Ireland. In those countries the limestone series seems to have been deposited during one long period of marine conditions, while in Scotland, the strata of the same period as characterised by its flora and fauna, show that alterations from old land surfaces, with their forests of vegetation, to lakes and sea bottoms, were repeated again and again during its formation; the organisms found in the sedimentary strata clearly pointing out those beds which were laid down over sea bottoms, as well as those deposited

* Prof. Hull's paper has since been printed in full, with lists of characteristic fossils, in the Quarterly Journal of the Geological Society of London, November, 1877.

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under fresh-water and estuarine conditions. The fresh-water strata of the Carboniferous limestone series of Scotland are further characterised by a certain group of fossils that reappear in the purely fresh-water strata of our upper coal measures, but which are absent from the marine beds. These organisms consist of plants, crustaceans, molluscs, fishes, and reptiles, the genera and nearly all the species of which are found in both series of beds. The plants belong to the genera *Lepidodendron*, *Sigillaria*, *Calamites*, *Sphenopteris*, *Pecopteris*, etc.; the crustaceans to the group of the Ostracoda, five species of which are peculiarly characteristic of the fresh-water strata of the limestone series and upper coal measures. These are *Cythere* or *(Carbonia) fabulina*, *C. Rankiniana*, *C. pungens*, *C. secans*, and *C. subula*. The molluscs found in the same beds belong to the genus *Anthrocoptera*. The characteristic fishes are chiefly ganoid, none of them seeming to have lived under purely marine conditions, several genera being common to both series of beds. *Megalichthys* has the greatest vertical range, being found, along with the former group of organisms, from the strata of the calciferous sandstone series up to the higher beds of the upper coal measures. As *Megalichthys* has been found in a few instances associated with marine remains, it has been sometimes contended that its presence should not be taken as evidence of fresh-water or estuarine strata, but Mr. Young thought that every one who has collected specimens of this fish would agree with him when he stated that for every time it has been found under marine conditions it occurs ninety-nine times in strata where no characteristic marine organisms are found. At least this is the case in Scotland. It may have had the power of visiting the sea at intervals, or its hard mailed carcass may after death have been floated out from the rivers. However this may be, it is clear that fresh water was its usual habitat. It is therefore evident that any classification of Carboniferous strata formed on a palæontological basis to suit England and Ireland would not suit Scotland, where an entirely different set of physical conditions prevailed, regulating and influencing the varied life of the period.

Mr. Young concluded his remarks on the subject by observing that in the coal-fields of Scotland there is to be found clear evidence, in the entombed remains, of earlier conditions of land and fresh-water strata than those which obtained in England and Ireland. He would, therefore, prefer to see a palæontological

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classification which would be characteristic of each coal-field, but which, at the same time, would correlate, as far as possible, the strata of the several groups.

VI.—*Notes on the Limestone Strata of the District around Glasgow.* By JOHN YOUNG, F.G.S., V.P.

[Read 11th October, 1877.]

IN the following remarks it shall be my endeavour to point out some of the lithological and palæontological characters which distinguish the limestone strata in the Carboniferous system around Glasgow, especially as these limestones clearly indicate, in many of the beds, the conditions under which they were deposited, either from the growth of calcareous organisms over sea and lake bottoms, or from precipitation of lime held in chemical solution in their waters. In order to render my subject more clear, I shall take the beds in ascending order, commencing with those found in the calciferous series or Lower Carboniferous strata of this part of Western Scotland. The Lower Carboniferous beds in the district around Glasgow consist, first, of a lower group of red sandstones and conglomerates, formerly placed in the Old Red Sandstone system, and an upper group of thin bedded nodular limestones, dark grey marly shales, flaggy sandstones, and beds of a white or yellowish grey sandstone. These groups of strata, so far as characterized by their fossils, seem to be of lacustrine origin, the fossils being plant remains and fragments of ganoid fishes, none of which have been found in the limestones. In the lower red sandstone, limestone is very rare, but a bed several feet in thickness has been worked in this division at Balgair Moor, north of the Fintry Hills. It is a hard, fine-grained stone, greyish white in colour, but tinged red in many places by peroxide of iron; irregular in its bedding, dipping at a high angle to the south, and much traversed by thin bands or nodules of silica. This limestone is nearly a pure dolomite, containing 44 per cent. of carbonate of magnesia, and 53 per cent. of carbonate of lime. It contains no trace of organisms, and was probably deposited in a fresh-water lake by chemical precipitation of the excess of lime and magnesia held in solution by the water. A similar limestone, devoid of

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fossils, and of the same colour and structure, is found in the red sandstone on the hillside near Toward Point on the Clyde, and probably holds the same geological position. The limestone bands found in the red sandstone near Inverkip have as yet yielded no fossils, and, like that already noted, have evidently been deposited by chemical precipitation; they contain, however, much less magnesia than the bed at Balgair. Other bands of nodular limestone and calcareous strata have been noted in this red sandstone series in the Glasgow district, but they all agree in their unfossiliferous character, and in their mode of deposition. The limestone bands in the upper division of the calciferous sandstone series are numerous, but mostly thin bedded and nodular in character, being often traversed by cracks or septaria. They form the cement-stone series of the Scottish Geological Survey, and are well exposed in the sections along the base of the Campsie Fells to the westward, as well as in the Kilpatrick, Renfrew, and Ayrshire hills; their position when present being immediately under that of the overlying trap of that extended range of hills stretching along the country from Stirling to Ardrossan. The cement-stone series, as seen in the beautiful sections at the Spout of Ballagan, and in Auchenreach Glen in the valley of the Leven near Dumbarton, must be several hundred feet in thickness. The limestone bands alternate with layers of marly shale, which form more than two-thirds of the thickness of the group, none of the former being much over a foot in thickness, while others are barely an inch. The colour of these cement-stones varies in the several exposed sections from a dark to a light or creamy grey, while some are of a reddish tint, as in Ballagan Glen, from the presence of peroxide of iron in their composition. They mostly all weather into a lighter colour than their interior, by exposure to the atmosphere; those of Campsie Glen being of a light yellow tint on their outer surfaces, owing to the presence of oxide of iron. As formerly stated, many of these limestone bands are of a nodular structure, and those which have been segregated in this form by the withdrawal of the lime from the surrounding strata are found to be of the purest composition, being hard, fine-grained, and often breaking with a conchoidal fracture, though as a group these cement-stones are impure, earthy varieties of a dolomitic limestone.

The following analysis by our late respected member, Mr. J. Wallace Young, gives the chemical composition of one of the

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purest bands found at Ballagan, which may be taken, with slightly varying quantities of the several mineral constituents, as typical of the group :—

Clay and Sand, } Insoluble matter,	... ...	11·92 per cent.
Silicic Acid, } Insoluble matter,	... ...	1·67 ,,
Lime, ...		26·99 ,,
Magnesia, ...		17·21 ,,
Protoxide of Iron, ...		·64 ,,
Oxides of Iron and Alumina, ...		2·67 ,,
Carbonic Acid, ...		38·00 ,,
Loss, &c., ...		·90 ,,
		100·00 per cent.

Dried at 100° C.

In none of the localities where they are found have the cement-stones been much worked for industrial purposes, which is no doubt owing partly to the thin-bedded character of the strata, the poorer quality of the lime when compared with that of the Carboniferous limestone series in the same district, and because there are no associated coal beds in the group to assist in the burning of the stone in the kilns. In the strata which alternate with this group of limestones organisms are rare, and those that have been found are confined to the grey sandy shales, none being met with in the limestone. These fossils consist of drifted stems of a small *Lepidodendron*, fragments of undetermined plant remains, burrows and tracts of an annelid, and a few scattered scales of ganoid fishes. Taking the cement-stones in connection with the lower red sandstone group formerly noticed, the result of the fossil evidence shows that both groups of strata were accumulated in a large lake under fresh-water conditions, the limestones of both being chemically deposited from the water, and that the nodular structure seen in many of the bands was due to a further segregation of the carbonates of lime and magnesia from the strata, after the deposition had taken place.

The limestones of the above-mentioned red sandstone and cement-stone series, which form the calciferous or lowest division of the Carboniferous system in Western Scotland, are separated from the Carboniferous limestone series proper by a great thickness of bedded traps or ancient lava flows, which must have been poured out in this district, probably during the period when the later calciferous beds of other districts of Scotland were being deposited.

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These traps, which are over 1000 feet in thickness, are seen resting in the district around Glasgow upon denuded surfaces of the cement-stone series and lower red sandstone. Although interbedded sedimentary strata with plant and fish remains have been found locked up between these old lava flows in one or two localities, yet no calcareous strata have been met with until we come to the Carboniferous limestone series which lies immediately over the trap. When this position is reached in our coal-field we have abundant evidence of the presence of the sea during the deposition of many of the beds, as testified by the quantity of marine organisms. The limestones present us with three varieties, which may here be distinguished as, first, limestones of marine origin, almost entirely built up of various groups of organisms, such as crinoids, corals, molluscs, polyzoa, etc.; second, limestones, more or less impure, of marine origin of a fine grain and compact texture, in which fossils are not very abundant; and third, limestones, compact and of fine grain, which from their contained organisms have evidently been deposited in lakes under fresh-water conditions. The latter group of limestones is, however, much more limited in its area in the Glasgow district than the two former, being found only in that portion of the coal-field which borders the Campsie and Kilpatrick hills.

The first or fossiliferous group of limestones is found of varying colours, in some of the beds being nearly white, as at Trearne, near Beith, and grey or dark grey when mixed with carbonaceous matter, iron oxides, and other impurities, as is common with many of the other Lanarkshire and Ayrshire limestones. The texture also varies according to the nature and size of the contained fossils; when these are small and consist of a minute encrinal *debris*, as in the Hurlet and Campsie limestone, the rock is compact and fine grained, and the abundance of the organisms in the stone are not suspected until we examine a weathered surface which bring them into abundant relief. These richly fossiliferous limestones are not uncommon in the lower division of the Carboniferous limestone series of Lanarkshire, but it is in the Ayrshire district, around Beith and Dalry, where they attain their maximum thickness, and where they are extensively worked, that we perceive how much the growth of the several classes of organisms which they contain have contributed to their building up. In some districts these fossiliferous limestones are much deteriorated

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for industrial purposes by thin bands of silica which traverse them, and which have evidently been deposited along with the limestone while in chemical solution in the sea-water. When the limestone is composed of a calcareous organic *debris*, and is free from impurities, such as silica, clay, etc., we have often a rich deposit like that of Campsie and Hurlet, which contains 95 per cent. of carbonate of lime, it being one of the best of its kind, and much used for economic purposes. The second of these varieties of limestone is, as formerly stated, also of marine origin, but in it fossils are not abundant. The beds are locally termed "calm" or "cement" limestones in contradistinction to the fossiliferous limestones, which are termed "rough" limestones. The "calm" limestones are generally fine-grained, compact in texture, and often break with a conchoidal fracture. As regards their lithological character, they are of varying composition, some being well suited for various industrial purposes, and more especially that they have the property of setting under water with a firmer band than those of the purer fossiliferous limestones. This property is due to a certain admixture of silica and alumina, and probably a little magnesia, in their composition. Some of these "calm" limestones are worked specially as cement-stones, such as the Orchard limestone near Giffnock, and that of the Blantyre and East Kilbride districts. They are thin, seldom being found over two feet in thickness, and when viewed in section look more like hard bands of calcareous shale than limestones. They also often graduate into shale in some localities, through the absence of the calcareous elements. The thickest bed worked near Glasgow is that known as the Arden limestone, at Thornliebank, south of the Clyde; the Garnkirk, or Robroystone limestone, north of the Clyde; and the Linnspout limestone, in the Dalry district of Ayrshire; it varies in thickness in these localities from 6 to 10 feet or even more. It occupies a well-defined position in the strata, being taken by the Scottish Geological Survey as the division line between the Carboniferous limestone series and that of the overlying Millstone Grit. Besides being used for building and cement purposes, the bed has also been extensively worked for iron smelting. The "calm" limestones are generally of a grey or dark grey colour, but their surface becomes lighter from exposure to the atmosphere, and often assumes a yellowish tinge, owing to the presence of iron. As formerly stated, these limestones are not rich in fossils, the organisms they contain

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being often scattered at random, and at wide intervals throughout the stone. The slightest inspection of their weathered surfaces, or of the rotted material from their fissures, shows clearly that the basis of this variety of limestone was not an organic *debris*, but rather that it had been accumulated chiefly by chemical precipitation of the calcareous matter from the sea-water, the lime being deposited in combination along with the clay, sand, iron, etc. The groups of organisms found in the "calm" limestones and their associated strata do not differ much from those found in the fossiliferous beds, except in relative numbers. If there be any exception, it is that cephalopod shells are more often found in the strata of the former than in those of the latter group, this difference in the character of the fauna being probably due to depth of water and nature of the sediments then forming over the sea bottom.

The third group of calcareous strata, which lies within this division of the Carboniferous limestone series, comprises those beds which are apparently of fresh-water, or of lacustrine, origin. These limestones lie in the lower division of the series, and, so far as I am aware, have not been found out of the Campsie district, north of Glasgow. One of the beds, locally known as "the white limestone," from its light grey colour, is found from 3 to 6 feet in thickness, and although stated to contain 85 per cent. of lime, has not been much worked. Its position is immediately under the coal and limestone of the Hurlet and Campsie series. It is a hard, fine-grained rock, and so closely resembles the fresh-water limestone of the Burdiehouse group, in the calciferous sandstone series around Edinburgh, both in colour and texture, that it is often difficult, in hand specimens, to distinguish between the two. Like that of Burdiehouse, it is evidently a chemically-formed limestone, although occurring in a higher geological horizon. Its contained fossils are *Carbonia fabulina*, *C. pungens*, *Microconchus (Spirorbis) carbonarius*, *Rhizodus Hibbertii*, and *Stigmaria ficoides*, the upper portion of the limestone being much penetrated by the stigmarian rootlets, which have descended from the overlying coal-bed. Other thin bands of chemically-formed impure fresh-water limestones are found on other horizons within the Campsie district. Some of these weather on their surface to a bright orange colour, and have an imperfect kind of oolitic structure. Some appear to be non-fossiliferous, while others abound in the remains of Entomostraca, the species noted being *Carbonia fabulina*, *C. Rankiniana*, *C. subula*,

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C. secans, and *C. pungens*, along with a rare form found in the Millburn beds, *Macrocypris carbonica*. Plant and fish remains are always associated with these Entomostraca, as well as the little annelid *Microconchus (Spirorbis) carbonarius*. It may be of interest here to note that nearly all the above species of Entomostraca, as well as the annelid, are likewise characteristic of the fresh-water strata of the middle coal and ironstone series, as well as of similar strata in our upper coal measures. These fresh-water limestones and associated coal strata of the Campsie district clearly testify to depressions and upheavals of the land during the deposition of the lower Carboniferous limestone series over this tract of country, and it is highly probable that these conditions extended into other tracts of the western Scottish coal-field, although lacustrine limestones may not have been deposited over these tracts.

In the Millstone Grit series one or two limestone bands have been noted. They are generally impure varieties of the "calm" or cement limestone, and the few fossils they have yielded are all of species belonging to the Carboniferous limestone. The thickest and best bed is that of Levenseat, found on the eastern border of the Lanarkshire coal basin, about 9 feet in thickness, but apparently of local extent. According to Dr. William Grossart, the Levenseat limestone lies 30 fathoms above the horizon of the Gair, or Robroystone, limestone, which, as formerly stated, is now made by the Geological Survey the boundary line between the Carboniferous limestone series and that of the Millstone Grit.

No limestones have been found in the strata of the upper coal measures within the Glasgow district, this group being composed of a series of beds which have accumulated from the growth of the vegetation that lay over the land, and as river sediments over shallow lake bottoms, the conditions of the waters of the period not being favourable to the formation of limestone or other calcareous strata.

The following tables show the number of limestone beds in the Lanarkshire and Ayrshire Carboniferous basins in their descending order, the average thickness of each bed being given. The Lanarkshire district taken is that of Carluke, where the limestone strata have been well studied by Dr. Rankin, Dr. J. S. Hunter, and the staff of the Scottish Geological Survey—the list of beds being taken from that printed in the Memoir of Explanation to Sheet 23 of the Survey Map, pp. 23–4. The Ayrshire district is that of the Beith

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and Dalry basins, which has been well studied by Mr. Robert Craig, the average thickness of the limestones being taken from his papers, printed in the Transactions of this Society, Vols. III., V., and VI.:—

CARLUKE DISTRICT (Upper Limestone Series)—

	Feet.	Inches.
Gair Limestone (Robroystone and Arden Limestone of Glasgow District), ...	4	6
Gillfoot or Belstanburn Limestone, ...	4	0
Belstan Limestone (Index Limestone), (Cowglen Limestone), ...	4	0

CARLUKE DISTRICT (Lower Limestone Series)—

Limestone, ...	1	9
Limestone (Calmy), (*Lingula* Limestone of Dr. Rankin),	1	6
Limestone (1st Kingshaw Seam), ...	2	0
Limestone (Local, of Raesgill), ...	0	5
Limestone (2nd Kingshaw, Wee, or Lady Seam), (Guildhouse Limestone), ...	2	10
Limestone (Calmy, Birkfield Seam), (1st Calmy Limestone of Dr. Rankin), ...	4	6
Limestone (Foul or Hosie Seam), (Hosie Limestone, Campsie District), ...	3	6
Limestone (Calmy), (2nd Calmy Limestone of Dr. Rankin),...	2	6
Limestone (Main Seam), (Limestone of Campsie and Hurlet Districts), ...	5	3
Limestone (Coarse), ...	2	0
Limestone (Coarse), ...	1	5
Limestone (Wee Limestone of Lesmahagow and Douglas Districts?), ...	1	6
Limestone (Oyster Seam), (*Productus giganteus* Limestone of Dr. Rankin), ...	4	0
Limestone (*Productus punctatus* Limestone of Dr. Rankin), ...	0	3
Limestone, ...	0	6
Total Thickness, ...	46	5

NOTE.—For list of fossils from the above group of Limestone strata, see "Memoir of Explanations to Sheet 23 of Geological Survey," and "Catalogue of Western Scottish Fossils," prepared for the Glasgow Meeting of the British Association, 1876.

BEITH AND DALRY DISTRICTS (Upper Limestone Series)—

	Feet.	Inches.
Limestone (Linn Spout, upper), Dalry District, ...	42	0
Limestone (Linn Spout, lower), Dalry District (Arden Limestone, Glasgow), ...	36	0

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	Feet.	Inches.
Limestone (Bowertrapping), Dalry District, ...	4	0
Limestone (Highfield), Dalry District (Index or Cowglen Limestone), ...	6	0
BEITH AND DALRY DISTRICTS (Lower Limestone Series)—		
Limestone (Upper Thick Post)—Hillhead, Trearne, Beith District; Cunningham-Baidland, Auchenskeoch, etc., Dalry District, ...	40	0
Limestone (Lower Thick Post)—Langside, Broadstone, Roughwood, Beith District; Auchenskeoch, Auchenmade, etc., Dalry District, ...	20	0
Total Thickness, ...	148	0

NOTE.—For list of fossils found in these limestones, see Mr. Craig's Papers, and "Catalogue of Western Scottish Fossils," *ut supra*.

On comparing the thickness of calcareous strata in the Lanarkshire and Ayrshire basins it will be seen that while there are fewer beds of limestone in the latter basin, they are much thicker, and approach more in character to that of the Carboniferous limestone of other countries. The upper limestone series of the Dalry district is chiefly of the "calm" or impure earthy variety, and is never so highly fossiliferous as the beds of the lower series of the same district. At present the upper limestones are not much worked for any industrial purpose, but in former years quarries were opened in the several beds at various localities, where sections of the strata can still be seen, and where specimens of the organic remains may yet be obtained from the limestones and shales.

The limestone of the two lower thick posts of the Beith and Dalry districts have long been extensively worked for iron smelting, as well as for building and agricultural purposes, and large quarries have been opened in these beds at their outcrops at several points in the basin. In the working of some of these quarries the limestone, according to Mr. Craig, is found to change rapidly in its character by intercalations of shale, which reduces the thickness and quality of the limestone, as well as splits it up into a series of thin beds so little worth working that quarries have had to be abandoned on this account alone. Looking, therefore, at the limestones of the Lanarkshire and Ayrshire coal-fields, one can easily perceive that the reason why no thick or persistent beds were laid down over the areas of these coal-fields was due to the great amount of sedimentary deposits carried into their basins by

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rivers, the conditions favourable to the growth and continuance of the organisms which built up the limestone strata being thereby destroyed. We apparently have no thick limestones in our marine series, which have been formed exclusively from the growth of foraminiferal organisms like that of some other countries, or which can be regarded as a very deep-sea deposit, like that forming over the floor of the Atlantic and Pacific sea-bottoms at the present day. Looking at the whole group of organisms found in our limestones, in connection with the several coal seams and other varying sedimentary strata, the conclusion is forced upon us that they were formed over comparatively shallow tracts of the sea-bottom, which during this period suffered numerous upheavals and depressions, as is clearly testified by the varying nature of the strata.

VII.—*The* Internal Condition *of the* Earth; *as to* Temperature, Fluidity, *and* Rigidity. By Sir William Thomson, LL.D., F.R.S., &c., Professor of Natural Philosophy in the University of Glasgow, President.

[Read 14th February, 1878.]

On previous occasions I have referred to the various arguments that have been adduced with reference to the interior condition of the earth, and to the different grounds on which it may be concluded that, instead of being a liquid mass enclosed by a mere thin shell of solid material, the earth must be, on the whole, solid.

That there is some liquid within the earth is not to be denied. Immediately before lava breaks forth in the eruption of a volcano there is liquid in the interior; and, from the phenomenon of volcanic eruptions, we know that there is sometimes, and may be always, some liquid in the earth's interior. How much liquid there may be—how much it is necessary to assume in order to account for the known phenomena of volcanic eruptions—cannot be estimated with any degree of definiteness; but I hope to be able to put before you, this evening, arguments which will convince you that we cannot admit that there is any great liquid ocean under the earth's surface, and that we are forced to look to local causes for the explanation of volcanic eruptions.

The main reason given for supposing the interior of the earth to be fluid is not, however, the existence of volcanic phenomena.

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From considerations regarding underground temperature, many geologists have been led to hold as a geological truth that the interior of the earth is molten throughout.

The evidences of a high internal temperature are well known. It is found by observation that, passing downwards from the surface, we meet first with a thin stratum in which variations of temperature, due to the conduction inward of summer heat and winter cold, are perceptible. This stratum is on the average about 10 metres thick. Its thickness, however, is different in different localities. It depends on the thermal conductivity of the rocks composing it. At greater depths than about 10 metres the effect of the variations of external temperature with day and night and with the seasons is not sensible. As we go down lower and lower we find that the temperature of the strata increases steadily. Speaking roughly, we find that, on the average, the increase of underground temperature in ordinary localities is about 1° C. per 30 metres of descent, or about 1° F. per 50 feet.

There are localities, such as Kreuznach in Rhenish Prussia, in which the rate of increase of underground temperature, as we proceed downwards, is much greater than this. These are places, no doubt, where disturbances, in the way of great outbursts of lava, have recently taken place; and I may suggest, that careful observation of the rate of increase of underground temperature, in places where the date is known of a recent disturbance, would be of great importance, and would give us the means of inferring something regarding the geological history of places where an extraordinary rate of increase is observed. It is not, however, my purpose, at present, to enter into any speculation regarding geological dates in cases such as these, but rather to put before you considerations with respect to underground temperatures in general, which in the first place seem to indicate internal fluidity, but which, when further studied, do not really lead us to any such conclusion, but rather lead us to suspend our judgment, and to look in other directions for evidences of the internal condition of the earth as to whether it is fluid or solid.

From the observed increase of temperature downwards below ground in all localities, we must conclude that the earth had, at some time more or less remote, its whole surface at some very high temperature. It may have been red-hot and solid all round; but it is far more probable that the surface, at least, was molten all over; and

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it is quite likely that the hypothesis more commonly held—namely, that it was molten throughout—is true. The most probable hypothesis that has been given for the early history of the earth is, that it was built up by the falling in of meteoric matter, and that the matter falling in with great velocity, acquired through gravitation, became heated by collision. If this hypothesis is true, the heat caused by the collisions, after the earth had grown to be anything approaching to its present size, would be far more than sufficient to melt the material falling in.

Let us now consider a liquid globe, and suppose it to cool as does lava. The result of the cooling is that as soon as any portion of the matter reaches a temperature below the melting point, it freezes and becomes solid. Instead of molten lava, it becomes solid rock. And now comes the great question—will the solid rock thus formed sink or float? I wish this question could be answered. We have at present very little information on the subject—none of a definite kind, so far as I know, except that given us by the experiments of Bischoff.* Bischoff, experimenting on trachite, granite, and basalt, found the solids in these three cases about 10 per cent. denser than the liquids.

This is a subject on which we ought to have better information, and I do think that physicists are at fault for not having given information regarding it to geologists. Speaking, on the other hand, in the capacity in which you do me the honour to place me, we, the geologists, are at fault for not having demanded of the physicists experiments on this subject. . This time last year I urged that some one should take up the subject. I now renew the suggestion. We have a great Government fund for scientific inquiry. Why do not physicists and geologists unite in an inquiry like this, and apply for assistance out of the Government grant fund? They should then repeat Bischoff's experiments and test his results, but on a far larger scale, and extend the investigation to many materials besides those he used.

In the meantime, the only experimental evidence we have is to

* Since this Address was delivered, some important experiments have been carried out at the request of Dr. Henry Muirhead, by Mr. Joseph Whitley, of Leeds. His experiments were made on iron, copper, and brass, and on whinstone and granite, and the general result, hitherto arrived at, seems to be that these substances are *less* dense in the solid than in the liquid state at the melting temperature.

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the effect that the melted rock is of less specific gravity than the solid rock, and that the solid rock would therefore sink down when frozen. Without insisting on this as being proved, I shall just call your attention to what would be the probable history of the solidification of a molten globe if this were the case. As soon as the surface began to freeze, and to freeze in sufficient quantity not to be floated up by mere superficial solidified foam, the mass of rock would fall down towards the centre. More would then solidify at the surface. This also would fall down, and the same thing would go on again and again. Gradually a sort of honey-combed solid would be formed. By-and-bye a skeleton or frame-work through the whole would mount up to an extent sufficient to build up piers, as it were, to the surface, and the spaces between these piers when close enough would, in the continued freezing of the lava, be bridged across by solid rock thick enough in proportion to breadth not to break down and sink. There would, again, be breaking away of the piers and upheavals of the liquid material below; but by degrees the honey-combed mass would become nearly like a solid throughout with comparatively small interstices of liquid lava. This is in part the view of Hopkins. On account of arguments drawn from the phenomena of precession and nutation he was led to regard the earth as rigid on the whole; and, looking to the existing evidence as to geological phenomena, he was led to hold a view of the probable history of the earth agreeing with that which I have sketched, at all events so far as it would lead to the supposed present honey-combed condition.

Hopkins considered other very important questions, and among these was the question of the influence, on their condition as to solidity and fluidity, of the great pressure to which the interior parts of the globe are subjected. He made experiments as to the influence of pressure on the melting points of some fusible substances, though he was not able to extend them so far as to test the effect of pressure in altering the melting point of rock materials.

Without making direct experiments, however, as to the influence of pressure on the melting point of rocks, we are able to infer by thermo-dynamic reasoning what must be the effect of pressure on the temperature of fusion, if we know whether rocks expand or contract in the act of solidifying. My brother, Professor James Thomson,

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has pointed out that it is a necessary consequence of thermo-dynamic laws that the temperature of the melting points of substances which expand in solidifying should be raised by the application of pressure, while the opposite would be the case with substances which contract in becoming solid. Water, for instance, expands when it freezes: and he calculated the amount by which the freezing-point of water ought to be lowered by the application of an additional atmosphere of pressure. He found it to be about $\frac{3}{40}$ of a degree Fahrenheit; and his theoretical result was afterwards verified by experiments made in the incipient Physical Laboratory in the old buildings of the University of Glasgow. Now, if the result announced by Bischoff, that the rocks he examined contract during solidification, be correct, it would follow as a consequence of thermo-dynamic laws that these substances melt at a higher temperature under high pressure than that at which they melt under low pressure. The conclusion to be drawn respecting the internal condition of the earth is, that we are not to infer liquidity of the interior, even if we should find evidence of a much higher internal temperature than that which would melt the rocks under ordinary pressure.

The view which I wish to put before you just now, however, is of a very different nature. I mean to deny altogether the intensely high temperature which Hopkins accepted, and the liquifying effect of which he endeavoured to obviate by introducing considerations regarding the solidity of the rocks, in consequence of intense pressure, even at very high temperature. It is too generally supposed that the rate of increase of underground temperature as we proceed inwards is uniform, or nearly so, and that as we penetrate mile after mile we should still find the temperature increasing with equable rapidity. Thus, if we take metrical measurement and the Centigrade scale of thermometry, we find an increase in temperature as we go downward of 1° C. per 30 metres of descent. This, if we suppose the rate of augmentation of temperature uniform, would give 1000 degrees at 30,000 metres, and 3333 degrees at a depth of 100 kilometres. One hundred kilometres is about 60 statute miles; and thus at 60 miles below the surface we should have a temperature of about 3000 degrees Centigrade. This is a temperature far higher than would be required to melt any of the ordinary rock materials at ordinary pressure. But what I want to ask now is, "What reason have we for supposing that, as

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we proceed farther and farther in, the temperature does go on increasing at this rate?" The only answer given is, that no falling off in the rate of increase of underground temperature has been found at the greatest depth to which observation has reached, and therefore none is to be expected at greater depths, at all events so far as 50 or 100 miles down.

"Now I have to remark upon this argument that the greatest "depth to which we have reached in observations of underground "temperature is scarcely one kilometre; and that if a 10 per "cent. diminution of the rate of augmentation of underground "temperature downwards were found at a depth of one kilometre, "this would demonstrate * that within the last 100,000 years the "upper surface of the earth must have been at a higher tempera-"ture than that now found at the depth of one kilometre. Such "a result is no doubt to be found by observation in places which "have been overflown by lava in the memory of man or a few "thousand years further back; but if, without going deeper than "a kilometre, a 10 per cent. diminution of the rate of increase of "temperature downwards were found for the whole earth, it would "limit the whole of geological history to within 100,000 years, or, "at all events, would interpose an absolute barrier against the "continuous descent of life on the earth from earlier periods than "100,000 years ago. Therefore, although search in particular "localities for a diminution of the rate of augmentation of under-"ground temperature in depths of less than a kilometre may be "of intense interest, as helping us to fix the dates of extinct "volcanic actions which have taken place within 100,000 years or "so, we know enough from thoroughly sure geological evidence "not to expect to find it, except in particular localities, and to "feel quite sure that we shall not find it under any considerable "portion of the earth's surface. If we admit as possible any such "discontinuity within 900,000 years, we might be prepared to find "a sensible diminution of the rate at three kilometres depth; but "not at anything less than 30 kilometres, if geologists validly "claim as much as 90,000,000 of years for the length of the time

* For proof of this and following statements regarding underground heat, I refer to "Secular Cooling of the Earth," *Transactions of the Royal Society of Edinburgh*, 1862; and Thomson and Tait's *Natural Philosophy*, Appendix D.

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"with which their science is concerned. Now this implies a "temperature of 1000° Cent. at the depth of 30 kilometres, allows "something less than 2000° for the temperature at 60 kilometres, "and does not require much more than 4000° Cent. at any depth "however great, but does require at the great depths a tempera-"ture of, at all events, not less than about 4000° Cent. It would "not take much 'hurrying up' of the actions with which they "are concerned to satisfy geologists with the more moderate "estimate of 50,000,000 of years. This would imply at least "about 3000° Cent. for the limiting temperature at great depths. "If the actual substance of the earth, whatever it may be, rocky "or metallic, at depths of from 60 to 100 kilometres, under the "pressure actually there experienced by it, can be solid at temper-"atures of from 3000° to 4000°, then we may hold the former "estimate (90,000,000) to be as probable as the latter (50,000,000), "so far as evidence from underground temperature can guide us. "If 4000° would melt the earth's substance at a depth of 10 "kilometres, we must reject the former estimate though we might "still admit the latter; if 3000° would melt the substance at a "depth of 60 kilometres, we should be compelled to conclude that "50,000,000 of years is an over-estimate. Whatever may be its "age, we may be quite sure the earth is solid in its interior; not, "I admit, throughout its whole volume, for there certainly are "spaces in volcanic regions occupied by liquid lava; but whatever "portion of the whole mass is liquid, whether the waters of the "ocean or melted matter in the interior, these portions are small "in comparison with the whole; and we must utterly reject any "geological hypothesis which, whether for explaining underground "heat or ancient upheavals and subsidences of the solid crust, or "earthquakes, or existing volcanoes, assumes the solid earth to be "a shell of 30, or 100, or 500, or 1000 kilometres thickness, "resting on an interior liquid mass." *

The state of the case then is, that we have no reason from anything that has been observed, or that could have been observed, at depths to which we have already penetrated, for concluding that the rate of increase of underground temperature, observed at small depths beneath the surface, continues uniformly as we proceed

* Quotation from the opening Address by Sir W. Thomson, as President of Section A, British Association, Glasgow Meeting, 1876.

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inwards; and that any argument for intensely high temperature within, based on the assumption that the rate of increase does exist undiminished at considerable depths, falls to the ground.

The accompanying diagrams, drawn to scale (*Natural Philosophy*, Thomson and Tait, Vol. I., Appendix D) show the *rate of augmentation*, and the *augmentation*, of underground temperature as we proceed downwards, on the assumption that the true rate of augmentation of temperature, after the superficial layer affected by summer heat and winter cold has been passed, is 1° Fah. per 51 feet at the beginning, and that the diminution in rate of augmentation of temperature is 10 per cent. per 30 kilometres, or 100,000 feet. Fig. 1 shows the rate of augmentation of temperature as we proceed downward. Distances measured in the direction OX are depths below the surface, the unit length being 400,000 feet. Thus the position of the point P′ in the diagram represents the state as to rate of augmentation of temperature at about ·7 of 400,000 feet, or 57,000 feet, below the surface. Ordinates measured outward on the diagram from the line OX represent rate of augmentation of underground temperature, the length OA being 1° F. per 51 feet. Thus at P′ the rate of augmentation is between six and seven tenths of 1° F. per 51 feet, and you must notice how rapidly the falling away takes place. At R, which is about 600,000 feet below the surface, the rate of augmentation is only one-tenth of a degree per 51 feet, and at the point S, less than 1,000,000 feet below the surface, it is sensibly zero. Beyond this point underground temperature does not sensibly increase.

Fig. 2 shows the excess of temperature above the surface temperature at various depths, assuming the rate of augmentation of temperature used in fig. 1. The depths are measured along OX, and the temperature at each depth is measured outward from the line OX to the curve. The length OA represents 7900° F. Thus you will see that the temperature at P′, 600,000 feet below the surface, is not so much as three times as high as the temperature at P, which is 100,000 feet below the surface, while at S, less than 1,000,000 feet below the surface, a maximum temperature of 7000° F. is reached.

Now, I do not presume to fix within any limits, even of rough approximation, what the greatest temperature reached in going downward may be. It may be 4000° F., or 5000°. It may possibly

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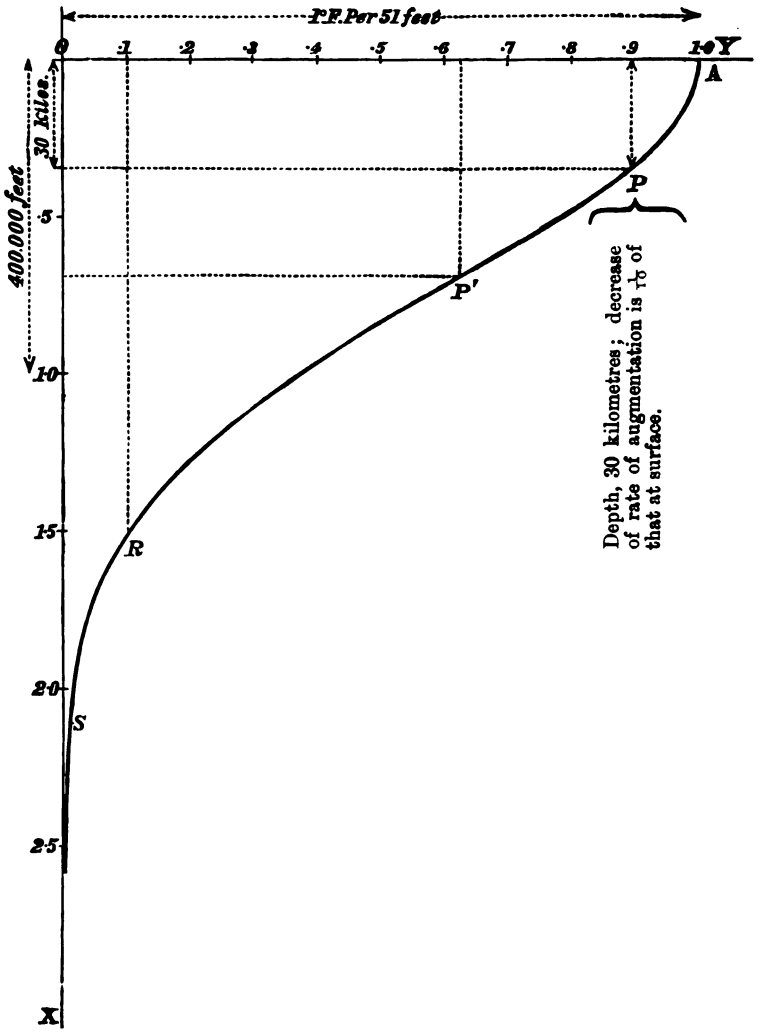

I. Curve showing Rate of Augmentation of Temperature downwards.

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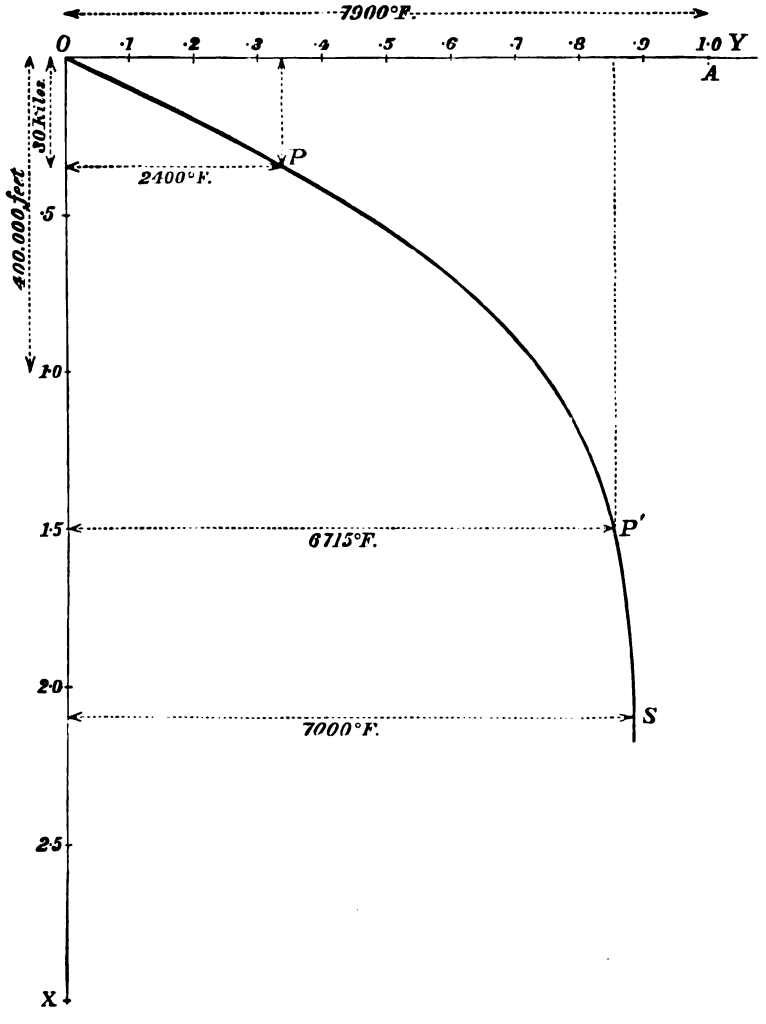

II. Curve showing Excess of Temperature above Surface Temperature, assuming the rate of augmentation of temperature indicated in Curve I.

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be 8000° or 10,000°; but there is a vast difference between five or ten thousand degrees and the one hundred thousand or million degrees, which we frequently find in geological disquisitions, and against which we do not find sufficient argument, or any argument at all, so far as I am aware, in any regular geological teachings, or published papers or books.

It appears, then, from the considerations that I have brought before you, that we must give up the argument derived from the phenomena of underground temperature as to the internal fluidity of the earth. They show that the earth's interior is at a high temperature, but not at any temperature so high as to make general rigidity of the earth's interior impossible or improbable. This being the state of the case, we are forced to look to arguments drawn from other sources to decide the question as to solidity or fluidity,—arguments such as are supplied to us from the phenomena of precession and nutation of the earth and from the phenomena of the tides. These arguments have been discussed in detail in a paper on the Rigidity of the Earth,* and in Thomson and Tait's *Natural Philosophy*, Vol. I.; and more recently in my Address to the Mathematical Section of the British Association at its meeting in Glasgow. The arguments derived from the phenomena of precession and nutation present considerable difficulties, and indeed do not afford us at the present time a decisive answer. The phenomena of the tides, however, lead us to no uncertain conclusion. Suppose the earth to consist of a thin shell or crust enclosing, or floating on, a vast interior of molten matter. The liquid interior would tend to yield freely to the tide generating influence of the sun and moon. The consequence would be that the exterior crust would be acted on by forces which, unless it were of preternaturally rigid material (I shall give you numbers directly), it would be unable to resist. The crust would then be subject to upheavals and depressions taking place in time with the revolutions of the sun and moon. If the crust yielded *perfectly*, there would be no tides of the sea, no rising and falling relatively to the land, at all. The water would go up and down with the land, and there would be no relative movement; and in proportion as the crust is less or more rigid the tides would be more or less diminished in magnitude. Now we

* "On the Rigidity of the Earth." W. Thomson, *Trans. R.S.*, May, 1862.

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cannot consider the earth to be absolutely rigid and unyielding. No material that we know of is so. But I find from calculation* that were the earth *as a whole* not more rigid than a similar globe of steel the relative rise and fall of the water in the tides would be only $\frac{2}{3}$ of that which it would be were the rigidity perfect; while, if the rigidity were no greater than that of a globe of glass, the relative rise and fall would be only $\frac{2}{5}$ of that on a perfectly rigid globe.

"Imperfect as the comparison between theory and observation "as to the actual height of the tides has been hitherto, it is scarcely "possible to believe that the height is only two-fifths of what it "would be if, as has been universally assumed in tidal theories, the "earth was perfectly rigid. It seems, therefore, nearly certain, "with no other evidence than is afforded by the tides, that the tidal "effective rigidity of the earth must be greater than that of glass." This is the result taking the earth as a globe uniformly rigid throughout. That a crust fifty or a hundred miles thick could possess such preternatural rigidity as to give to the mass, part solid and part liquid, a rigidity, as a whole, equal to that of glass or steel is incredible; and we are forced to the conclusion that the earth is not a mere thin shell filled with fluid, but is on the whole or in great part solid.

VIII.—*On the* Discovery *of* Whale Remains *in the* Clays *of the* Carse *of* Stirling. By James F. Stewart.

[Read 1st November, 1877.]

On the farm of Woodyet, on the estate of Meiklewood, about a mile to the east of Gargunnock, one of the stations of the Forth and Clyde Railway, there existed for a lengthened period a brick and tile work, which has, however, been disused for a good many years. This work was situated in a field about a couple of hundred yards to the north of the turnpike road, which is 38 feet above sea level, north of and close to the railway, and on the outer bank of a curve of the Forth. In this district the windings of the river are so numerous and extensive that it may be said to run to all points of the compass. To a depth of about four feet the clay was fit for use, but below that it became so soft as to be

* Thomson and Tait, *Natural Philosophy*, Vol. I., § 842.

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unworkable. As an instance of this, I may mention that when farm-steadings or dwelling-houses are built in the Carse lands the foundations must be laid on the surface of the ground, otherwise the walls are certain to sink and to be thrown off the perpendicular. Again, the railway bridge across the Forth at Gargunnock, and which was built of wood, fell one day a few years ago with a crash. The railway directors proposed to replace it with an iron structure, and a bore was put down on the river side to find foundations. After going down, it is said, to a depth of 170 feet without finding rock, the idea was given up, and another wooden bridge put up in place of the old one. The field whence the brick clay was excavated, though somewhat irregularly, exhibits depressions where the water lodged to the injury of the crops. To remedy this state of things, a main drain, with some offshoots, was in April last led from the river bank, and at a point 100 yards therefrom the workmen came upon six joints of the vertebræ of a whale. These were found in the large drain, about 12 feet below the original surface of the ground, and lying in a line inclined upwards, and in the direction of north-west to south-east. One would almost imagine that the animal had been stranded in shallow water, and was making for the sea when its progress was arrested for ever. About 8 feet from these another joint was found, and lying about 3 feet below the present surface. Afterwards three others were discovered, but not in line, and latterly the skull itself was found. The first six and the solitary joint were taken out by two workmen, and the others by a person employed to search for them. The position in which the bones were found in the dark-blue unctuous clay may be put down about 32 feet above mean sea level, as indicated on the ordnance map, or perhaps a little lower. Having been several times on the spot, I was requested to send a specimen of the clay in which the bones were embedded to a distinguished member of your Society, Mr. David Robertson, F.L.S., F.G.S., for his inspection and examination. I accordingly made up a parcel, containing also some scrapings from the skull, which had then been exposed to the weather for some days, and Mr. Robertson has since favoured me with the following report:—"October 10th, 1877.—I have examined the clay taken from under the whale bones found at Meiklewood that you so kindly sent me. It contained numerous species (about 15) of small marine Ostracoda and Foraminifera,

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and all belonging to those of our present seas. The clay is very pure, almost free from gravel or sand, and leaving little residue when washed, with the exception of the debris of the eroded cellular bone, which, I presume, came chiefly from that scraped off the skull. There can be little doubt that the evidence, so far as I have seen, shows that the animal belonged to a period posterior to the prevalence of a more general Arctic or glacial fauna in our seas." The whole of the excavated bones are now at the mansion-house of Meiklewood, where they have been examined by numerous visitors, amongst others by Professor Turner, of Edinburgh. The excavations have, however, been put a stop to, the hole filled up, and the field sowed, or about to be sowed, with winter wheat, so that a long time may elapse before an opportunity occurs for renewing the search for further portions of this cetacean skeleton.

IX.—*On* Retiolites. By James Dairon, V.P.

[Read 6th December, 1877.]

The genus *Retiolites* was founded by Barrande, who described one species, *R. Geinitzianus*, which he obtained from the upper Silurian rocks of Central Bohemia, and figured in his valuable Memoir upon the Graptolites of that country, published in 1850. This genus is one of the most interesting of those belonging to the Graptolitic group, but unfortunately our knowledge of its structure is but limited, and must, I think, remain so until a suitable collection of specimens, in a more perfect condition than hitherto attainable, has been formed and carefully studied. In its general outward appearance the genus *Retiolites* resembles those of *Diplograpsus* and *Climacograpsus*, in having a central stipe or solid axis, to which is attached a double row of cells or hydrothecæ, giving it a rather leaf-like appearance, but widely differing from these forms in its internal structure. It may be remembered that about four years ago I brought forward a specimen, which I named *Retiolites branchiatus*, and which was a beautiful example of the genus, from the lower Graptolitic shales of Dobb's Linn, near Moffat. Being in that neighbourhood again during the past summer, I was fortunate enough to obtain a number of various forms, including a new species of *Retiolites*, differing entirely from anything I had hitherto got at Dobb's Linn. It was found in the upper shales, show-

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ing that the genus had lived through the whole range of strata as represented in the Moffat beds. Amongst the many examples before you is one form to which I wish specially to direct your attention. You will easily perceive how widely it differs in its internal structure from some of the other species. The length of the fronds seems to vary from 3 to 4 inches, while their greatest breadth near the centre is $\frac{1}{4}$ of an inch. They have a long, slender stipe or solid axis in the centre, continuing beyond the distal extremity. To this stipe are attached, at an angle of about 30 degrees, the cellules, which are beautifully ornamented with a kind of lace or network, and this is placed around the cells from the outer margin to about half way on each side of the solid axis; the other two halves on the two sides of the stipe being filled in with a kind of hairy, irregular network; the solid axis at its distal extremity appearing to show a sort of double appearance. The cells at the outer edge are of a finely-rounded or convex shape, numbering about twenty-six to an inch, and are alternate on opposite sides of the frond, while they gradually diminish from three-quarters of its length to a lancet-shaped point. A question naturally arises as to the use of the framework around the cells. The cellules are circular, that form being probably the best suited for the requirements of their inhabitants, and the way in which they are arranged round in alternate segments of a circle makes it evident that there could be no better method adopted to secure their shape and appearance. I will defer any farther remarks upon this interesting species until I have devoted more time to its examination than I have yet been able to do. *R. branchiatus* possesses quite a different arrangement, but the specimens do not, unfortunately, show the cells, as they have been worn away, and nothing is left but the fibrous skeleton. It clearly, however, possesses a solid axis, with alternate strong fibres, set apart at intervals of about 3-16ths of an inch, the spaces being filled in by a delicate hairy network. In this species the cells may perhaps have been of a quadrangular shape, as is the case in the typical form of Barrande already quoted. It seems that he did not believe in the existence of a solid axis in *Retiolites*, but thought that the appearance shown in his specimen of *R. Geinitzianus* was merely a part of the framework. Geinitz and Hall both believe that there is a solid axis, and Professor Nicholson is of the same opinion, while I think my specimens show there is little doubt on the subject.

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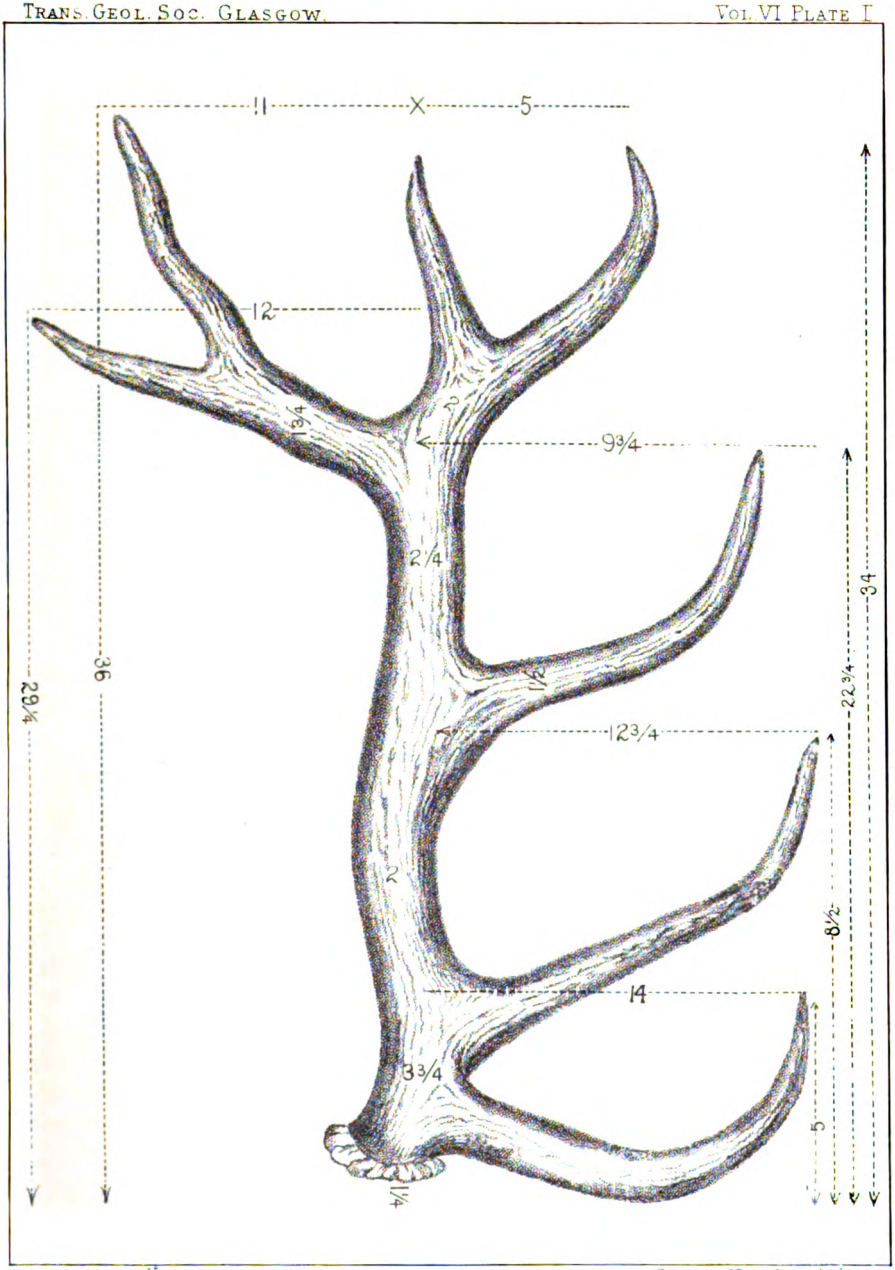

E. Bishop del.

Smith & Hamilton Lithog.

Antler of CERVUS ELEPHAS.

Found in Claybed at Paisley Gas Work.

(MEASUREMENT IN INCHES)

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X.—*On the* Post-tertiary Fossiliferous Bed *at the* New Gas Tank, Paisley. By David Robertson, F.L.S., F.G.S. With a Plate.

[Read 6th December, 1877.]

About fifteen years ago an excavation was made in Blackstone Road, Paisley, for a new gas tank, which we shall call No. 3, and distant about 100 yards from the two old tanks, Nos. 1 and 2. In that excavation marine shells of Arctic types were met with in great abundance in finely laminated clay. Trophons, in particular, were abundant, large, and in fine condition. Valves of the common mussel were lying closely together at some points, and crushed in thick cakes. A specimen of these may be seen in the Paisley Museum, but, so far as I can learn, there has, unfortunately, been no general collection of the shells preserved. During the past summer an excavation was made for a new tank, No. 4, on the site of the old tanks, Nos. 1 and 2, but extending 70 feet to the west beyond them, and were 130 feet in diameter, while the old ones were only 60 feet each. When it was known that this new tank was to be constructed, great hopes were entertained that the same beds of shells previously met with would be exposed. From the beginning to nearly the close of the excavation the work was carefully and hopefully watched, but, although shells were met with nearly from top to bottom, yet at no point were they in the abundance met with fifteen years previously at the excavation for No. 3 tank. Shells of the common mussel and *Mytilus modiolus* were plentiful, but in so very soft a condition that scarcely one could be taken out whole. *Tellina calcaria* was moderately common on the west side of the cutting, and was, it may be remarked, above the average size of those generally found in the Paisley clay-field. *Cyprina Islandica* was moderately common, while *Pecten Islandicus* was rather rare, nor was it nearly so large as specimens taken from the clay of tank No. 3, and now in the possession of Mr. Hislop, gas engineer of the works. One or two good specimens of *Fusus antiquus* were obtained, as well as a few of *Buccinum undatum*, mostly small or half-grown. The prevailing small shells were *Rissoa striata* and *Utriculus obtusata*, though not to compare in abundance or variety with those found in the previous excavation. These facts raised a suspicion in my mind that the deposit might be artificial,

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although this view was not wholly shared by those whose opinions were of any weight. This induced me to be careful in noticing any circumstance which might tend to prove or to disprove the exactness of my own theory. The find that attracted most attention was that of a horn of the Red Deer, *Cervus elephas*, 36 inches in height, with seven tines. I am indebted to Mr. Hislop for sending it here to-night for exhibition, and for affording me every facility and aid for examination during the progress of the excavation. This horn is in beautiful condition, and was met with 14 to 15 feet below the present surface of the ground. As it was found in the township of Paisley it has very properly been presented to the Museum, where it may henceforth be seen. I was present on the day when the workmen came upon it, and was shown the place from which it had been taken. It lay upon a bed of very soft black glairy mud, not the least like the stiffer clay prevailing in the section. On examining this I found that it contained abundance of Ostracoda and Foraminifera. I am not yet quite satisfied that the horn dates back to the period of the deposition of the marine clays. The Red Deer still exists in considerable numbers both in England and the Highlands of Scotland. Portions of their remains have been brought up in the Clyde near Bowling by the dredging machine, but I am not aware of them having been obtained from older deposits. Although marine Microzoa were found immediately beneath it, I cannot say that such was the case above it, for unfortunately the overlying clay had been removed out of the way, leaving no opportunity of testing whether they were there or not. It is therefore possible that the horn might be only lying on the top of the shell-bearing clay, and might have been carried down by a freshet or with some more buoyant material, and then dropped where it was found. You will observe that it has no appearance of having been abraded or water-worn. Had the overlying clay been found to be marine, containing Arctic shells, it might have been supposed that the horn belonged to that period, having been carried into the sea and covered with mud; but, taking all the facts of the case into consideration, there can be no doubt that the horn got there under different circumstances. The clay in the new tank (No. 4) excavation, down to the depth of 18 or 20 feet, was very black in colour, and had a forced and disturbed appearance, much of it along the west side being composed of blocks

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of red and black mould pressed together and traversed in all directions by numerous fractures, which were filled with patches of vivianite or blue phosphate of iron; and having no resemblance to that resulting from mud laid down on the sea-bottom, such as we find throughout the Paisley clay-fields. Taking into account the glairy black mud in which the horn was found, nothing could be more likely than that there had been an old clay-hole, into which the horn might in a variety of ways have accidentally got before it was filled up. In the neighbourhood of towns it is a common occurrence to come unexpectedly in the course of excavations upon the work of man, where all knowledge of its existence has dropped out of sight; and in the present instance it is most probable that one excavation was filled up with the outcome from another. A still more convincing proof that this deposit was artificial lies in the fact that at a depth of 19 feet a large piece of vitrified ash was dug out of the solid clay. It may be said that the cinder might possibly have got into the new cutting, and have been tramped into the clay under the feet of the workmen, but no one who saw it taken up from the solid block of clay, and thoroughly incorporated with it, as I did, could entertain any doubt that it had found its way there contemporaneously with the clay itself. At the still greater depth of 24 feet below the surface Mr. Hislop procured a beetle, *Carbera niteus*, in the clay, it being a common inhabitant of peaty soil. It may be stated that three bores which were put down preparatory to the excavation of tank No. 4 bear out the "higgledy-piggledy" character of the deposit. One of them was on the south, a second on the west, and the third on the north margin of the proposed excavation. The journal of these bores is as follows:—

No. 1 Bore on South Side.

	ft.	in.
Surface Soil,	2	6
Black Mud,	18	6
Sandy Clay,	3	0
Finer Clay,	3	0
Total,	27	0

No. 2 Bore on West Side.

	ft.	in.
Surface Soil,	3	6
Dark Mud,	16	6
Clay Mud,	7	0
Yellow Clay,	1	0
Total,	28	0

No. 3 Bore on South Side.

	ft.	in.
Surface Soil,	3	6
Sandy Mud,	6	6
Gravel Bed,	0	4
Dark Mud,	18	6
Total,	28	10

Extra Depth of No. 1 Bore.

	ft.	in.
Fine Yellow Clay,	9	0
Sand Bed,	0	4
Fine Clay,	1	8
Stony Clay,	1	0
Total,	12	0

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The whole cutting is within the radius of a few feet, yet the bores vary from each other to an extent that cannot be accounted for by the precipitation of mud in the ordinary way, but which agrees well with the character of an artificial deposit—a patch of one colour here and another there, and, notwithstanding the proximity of the bores, not two of them alike below the surface soil. Although the propriety of the names given by the workmen to the clay or other material taken from the bores may be questioned, as not agreeing with the usual geological nomenclature, yet these different names undoubtedly indicate variations as well as more scientific ones could have done. Yet the bores themselves give but an inadequate idea of the true arrangement of the deposit, while the cutting, when newly exposed, showed unmistakably the irregular way in which the deposit had been laid down. Upon inquiry, I have been told that no excavation had been made upon the site of the new tank for at least 60 years, and at that time the ground was covered with trees. The following extract from Mr. David Semple's "St. Mirin," with which Mr. Matthew Blair has favoured me, throws some light upon the very different earlier conditions of the locality. At page 140 Mr. Semple says,—"The Greenhill is a small mount about 16 feet higher than the surrounding land, and very probably received the name from its verdure of green. It would be a beautiful spot in olden times in the midst of the barren dreary waste, being bounded on the east and south by the Common, covered with indigenous wild moorland plants and shrubs; on the west by the Marsh of Finnie's Bog, the habitat of frogs and toads; and on the north by the Black Moss of Paisley, covered by heather and cotton grass. From the oldest volume of the Town Council records now extant, it appears that the good ground of Greenhill had been subdivided among the burgesses previous to the year 1594." Greenhill is the mount overlooking the gas-work, which work stands on a part of what was once Finnie's Bog. Now, we find that at the time Mr. Semple speaks of in the above extract the knoll called Greenhill stood in the midst of a barren dreary waste, covered with wild moorland plants and heather, cotton grass and bog myrtle. We now see a great change—the dreary waste converted into the site of large public works and beautiful pleasure grounds of villas and gardens. Taking a slight survey of the great changes which must have taken place, we cannot therefore be surprised if we come upon evidences of the works of man not known to the present generation. These

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particulars, however, will show the necessity of guarding against the drawing of hasty conclusions from such finds as that of the Red Deer's horn without making sure of all the conditions under which they are met with. As the list of fossils from this bed is almost identical with that published in our Transactions from the Paisley beds, it has not been thought needful to give it here. The fossils themselves may be seen in the Paisley Museum, to which institution I presented them after they were identified.

XI.—Additions *to the* List *of* Polyzoa *of* Garvel Park Post-tertiary Deposit. By David Robertson, F.L.S., F.G.S.

[Read 26th April, 1877.]

These additions were chiefly collected at the time the new dock was being opened in 1870. Some of the species which were new or little known could not be satisfactorily identified by the time that our Paper on this deposit was published in the Transactions of this Society, vol. iv., page 32; but although these additions to the list are long past date, they may be useful to those who have occasion to refer to the subject.

For their identification I am greatly indebted to the kind assistance of the Rev. A. M. Norman.

The additions are 15; those formerly published were 13, making in all 28 species of Polyzoa from this deposit, a total which is greatly larger than that obtained from any other locality in Scotland.

The list is as follows:—

Menipea ternata, var. Ellis and Solander.
Scrupocellaria scabra, var., *elongata*. Smitt.
Hippothoa catenularia. Jamieson.
Membranipora tuberculata. Busk.
Lepralia divisa. Norman.
,, *spinifera*. Johnston.
Escara struma. Norman.
,, *pateus*. Smitt.
Escharoides Sarsii. Smitt.
Tubulipora phalangea. Couch.
,, *serpens*. Linné.
Diastopora obelia. Fleming.
Discoporella flosculus. Hincks.
,, *Grignoniensis*. Busk.
Heteroporella radiata. Busk.

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XII.—Scottish Trap Rocks *and their* Structure *under the* Microscope. By Arthur Pratt.

[Read 17th January, 1878.]

About nine or ten years ago one of my boys brought me a piece of stone which he had picked up from amongst some ship's ballast lying at the river side, and which differed from anything I had before seen. I was amusing myself at the time by rubbing down pieces of granite, syenite, jasper, or anything in fact that I could find suitable for microscopic examination. I immediately set about getting a chip from the new find, and though to the naked eye it appeared as structureless as a bit of sealing-wax, I was astonished and delighted to find that, when placed under the lens it possessed a most beautiful crystalline structure. At the first opportunity I showed it to Mr. John Young, who pronounced it to be a piece of Arran pitchstone, though how it found its way amongst ships' ballast was not apparent, Arran being an unlikely place for a vessel to take in ballast. Since that time I have paid a visit to the Corriegills shore, where I got the pitchstone *in situ*, and have made many microscopic sections of it, some of them of still greater beauty than my first example, while some are rather plain, for there are degrees of beauty even in pitchstone. Since that time I have continued to make sections of any rock that I came across, but I had never thought of trying our common whinstone, till on one of the Society's excursions to Bowling, Mr. Young showed me the crystals of olivine in the trap rock there. When I put these under the microscope, I was so charmed with the whole structure of the rock that I began to collect and prepare specimens of trap from other places. Dumbarton Castle rock was the next I tried, and it showed a structure and general appearance so entirely different from the former one under the lens that I was quite puzzled. This was the starting point in the preparation of my Dolerite series. I may mention here that trap rocks have a wider interest than merely for road making—their common use—as the agriculturist finds that the fields lying over trap have a far superior soil to that formed by the disintegration of sandstone or clayslate, owing to the presence of potash, soda, and lime in their composition. A specimen which I now hand round gives a good

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example of the way in which the disintegration of trap takes place. Owing to the presence of iron in considerable proportions, the carbonic acid of rain water oxidizes and softens the outer surface of the mass, while the action of frost splits it up—in this case the concentric coats peel off like those of an onion. When resolved into its mineral constituents, the resulting soil contains those elements most suitable for building up vegetable fibre, and consequently the comparative luxuriance of the vegetation on the surface often guides a geologist to the nature of the underlying rocks.

Let us now take a glimpse into the inner structure of the trap rocks, and see how the microscope reveals beauties which we could never otherwise imagine. A piece of common road metal is a very unattractive looking object, but take a thin slice off it and place it under the lens, and I shall be much astonished if you do not get a surprise. I have here upwards of a hundred specimens from different localities—the Giant's Causeway, Arran, Argyllshire, Stirlingshire, Midlothian, Perthshire, Fifeshire; and nearer Glasgow, from Campsie, Gleniffer, Cathcart, Kilsyth, Bowling, Dumbarton, and, indeed, from every place where I could get good examples of the rock *in situ*. You will not, however, find any two of these alike, although all are essentially composed of the same elements, as may be seen by the following tabular statement of their chemical constituents:—

	Dolerite.	Basalt.	Felstone.	Pitchstone.
Silica, ...	51·0	48·0	75·4	70·6
Alumina, ...	14·0	13·8	15·0	15·0
Potash, ...	0·2	1·5	3·1	1·6
Soda, ...	3·4	3·0	6·8	2·4
Lime, ...	10·0	10·2	0·8	1·2
Magnesia, ...	5·5	6·5	1·1	0·6
Oxide of Iron, ...	14·7	13·8	2·3	2·6
Loss, ...	1·1	3·2	1·0	6·0

When ejected as molten masses from the interior of the earth, these rocks, when cooling, formed, according to the different proportions of the mineral elements present, crystals of augite, hornblende, plagioclase, felspar, magnetite, olivine, apatite, and other minerals. Again, by subsequent heating, and infiltration of water, some of them became altered into serpentine, &c. I have observed that those rocks of close texture and fine grain are always either bosses

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or vents or dykes, showing, I think, that the fine texture is caused not so much by quick cooling as by cooling under immense pressure. Those in larger masses, whether as intrusive sheets or overflows, are all of a coarse crystalline structure. Some of them are quite porphyritic in their character, showing that the segregation of their materials has been carried out in a slower manner. I have made drawings of a few to supplement the microscopic sections, and in order to make comparison more easy. I had cherished a hope of having been able to throw the sections upon a screen by the aid of the magic lantern, but the idea did not succeed, owing to the objects being so small that the structure was too imperfectly shown, and the colour of the crystals, which is the particular feature for distinguishing their arrangement and beauty, was entirely absent. I have therefore fallen back upon my original plan, and have asked my friends to bring their microscopes, so that there might be a possibility of showing most of the slides. In looking over them you will find a very marked difference between some of the specimens, even when from localities near one another. For instance, some specimens from the trap of the Necropolis show a great variety of crystals not to be seen in others, and vary much in their appearance. Most of the crystals are greatly altered through the infiltration of water—the mineral constituents being augite, plagioclase, felspar, magnetite, brown mica, apatite, olivine much altered, and a very few crystals of hornblende. Though a coarse-grained dolerite, it is a very pretty variety. The rock of Edinburgh Castle is of a dark close-grained texture, almost like a clink-stone, with numerous small grains of magnetite, and a few small crystals of augite much altered. Stirling Castle rock is a dark coarse-grained variety, with large patches of plagioclase-felspar, and numerous crystals of apatite and magnetite; it weathers very readily. Salisbury Crag and St. Anthony's Chapel are two very pretty varieties, but very different in character, though so near each other. Dumbarton Castle rock is a beautiful close-grained variety, with numerous small grains of magnetite and small clear crystals of felspar. Several specimens from this locality, taken from old rents, are filled up with a pretty green serpentine. Bowling Quarry has much larger crystals, and contains well-formed crystals of olivine, unaltered from their original pale green colour. As the quarry is being worked well into the hillside, that may account for their

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freshness. Jamie's Linn, at Campsie Glen, has a very fine-grained green variety, something like that of Dumbarton Rock, but much finer in texture. The specimen from Craigie's Linn is somewhat similar, but has large crystals of plagioclase-felspar, which give it a different appearance. Cathcart Castle rock is very much altered; the crystals of olivine are well shaped, but of a yellowish brown colour. There are some forms in this rock which I have not seen in any other, of a zeolitic appearance, with concentric rings, and radiated from their centres almost like a fine coral—they are of a bright yellow colour. There are also a number of compact felstones from different localities, some of a deep orange colour, and some amygdaloidal. Though very interesting, they do not show so well as some of the other crystalline forms for microscopic sections.

Before concluding these remarks, I may mention that if any one intends to begin making sections of rocks, let him be sure to keep a regular distinguishing mark or number upon each, a similar mark being entered in a book and continued during every stage of the grinding process, because if you have more than one specimen in hand at a time they are sure to get mixed without such a precaution, and from their changing appearance at different stages it will be impossible to identify them. During one winter I had prepared a number of slides, and knew them all by headmark, their localities, &c., but omitted to put particulars on the slides themselves. When summer came I got busy, and they were all laid aside for a time, but when I came to turn them over in the ensuing winter I found that I could not distinguish them, so that they were quite useless for the purpose of comparative examination. I was so annoyed that I took a good handful and put them in the ash basket. It was years before I got so many together again, but the circumstance taught me a lesson which I have never forgotten. I should mention that, in studying this subject, I have been much indebted to an admirable paper by Mr. Samuel Allport, F.G.S., published in the *Quarterly Journal* of the Geological Society of London, and to it I would draw your attention.

The following is my mode of procedure in preparing sections of rock specimens for the microscope:—Take a square-faced hammer, and chip off from a hand specimen a thin flake of the portion wanted, or one containing particular crystals. There must be no cracks in this, or it would be sure to go to pieces in the subsequent operations.

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Now grind one face of the chip on an iron plate with fine emery and water till it becomes quite flat and smooth, finishing on a Water-of-Ayr stone with water. Next take a piece of fine-grained wood (box or satin-wood suits very well) about 1½ inches square and ½-inch thick. On this fix your chip specimen with gum arabic, smooth side on the wood, and allow it to dry for a few hours. Proceed to grind the exposed face as before on the iron plate, using spirit of turpentine with the emery instead of water, and finish on Water-of-Ayr stone with turpentine, as it does not melt the gum fastening the stone as the water would. When the section has been sufficiently reduced, which a little experience will soon show, the next operation is to remove it from the wood, which must be done carefully to avoid the chance of breakage after so much trouble has been already expended upon it. Take hold of the wood by a pair of pliers, and hold it exposed to the steam from a boiling kettle for a minute, carefully wiping away all the gum round the specimen as it becomes dissolved. Steam it for five minutes or less, when it will slide gradually down to the edge of the wood. Lift it carefully with forceps, and lay it aside to dry, when it will be ready for mounting in the usual method, of which, for those who have had no experience, I will give a short description.

Having procured some slips of glass 3 inches long by 1 inch broad, the regulation size for microscopic slides, and some small discs of thin glass, put some Canada balsam into a wide-mouthed phial, and keep it by the fire till it is thin. Put a little balsam on the slide, on this lay the section, over it a little more balsam, on which place one of the thin glass discs, pressing it gently down. As the Canada balsam thickens very quickly, all this must be done as dexterously as possible, or you will not be able to get the various surfaces sufficiently close at first. If this is the case, subject the slide to heat, and then apply gentle pressure so as to get all the superfluous balsam and any air bubbles to the edges. After this object is attained, lay the slide aside for a few hours, when you can scrape off the balsam which has run over the edges with a penknife, and a soft cloth moistened with turpentine will brighten up the slide. By following this method rock specimens require no further sealing up, but if preferred a circle of Brunswick black varnish, or of white varnish, can be run round the glass circle by means of the turning table, which any microscopist will show you how to use.

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XIII.—A New Scottish Mineral (*Bowlingite*). By John Young, F.G.S.

[Read 7th March, 1878.]

The Kilpatrick Hills, near Bowling, in Dumbartonshire, have long been celebrated for the fine specimens of minerals of the zeolitic group, which their trap rocks have afforded. Here have been obtained the red Stilbites and Heulandites, as well as that of the Prehnites, Analcites, Thomsonites, and the rare Edingtonites, which now grace many a mineralogical collection, public and private, at home and abroad. The mineral from this district which I bring this evening before the society belongs to a different group from any of those that I have named. It forms one of the numerous group of minerals belonging to the Margarophyllite section of Professor Dana, of which he describes some thirty-seven species, arranged into eleven groups. They are hydrous silicates, in which the mineral Magnesia forms an important element, and which gives to many of the species in these groups that peculiar greasy or soapy feel which we recognise in Steatite or Soapstone. The name Margarophyllite has been given owing to the pearly lustre of many of the crystallized varieties, which resemble the mineral Mica in their laminated or foliaceous structure. Other varieties in this group have the compactness of clay or wax, and are in most instances the products of alteration of the mineral elements of the rock masses in which they are found; hence they are often of a somewhat varied chemical composition.

The new mineral, of which I now exhibit specimens, is found lining the sides of vertical, slickensided fissures in the basaltic Dolerite of the great whinstone quarry which is worked at the base of the Kilpatrick Hills, to the east of the village of Bowling, on the Clyde. It is of a dark, blackish-green colour, and is found in crusts adhering to the face of the rock, which vary in thickness from 1 inch to a mere film. In the thicker portions it is often traversed by thin lines of Calcite, the product of later infiltrations of lime into the fissures. It has long been known to the lessee of the quarry, Mr. John Scott, who tells me that it often gives the men

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considerable trouble when boring for the blasting operations, as, from its greasy nature, it frequently turns aside and bends the boring tools which come into contact with it. It has also been noticed in former years by members of this Society, both in the Bowling quarry and in the one on the Cathkin Hills, south-east of Glasgow, but it was always regarded as a Steatite by those who happened to collect specimens. Last summer, when paying a visit to the former quarry, I was fortunate enough to get some almost pure pieces of the mineral from Mr. Scott, and on comparing them with the other magnesian minerals of the same group, in the Hunterian Collection of the Glasgow University, I found I could not identify the Bowling specimens with any of them. I therefore placed examples in the hands of my friend, Mr. J. B. Hannay, F.R.S.E., F.G.S., for analysis. After a careful examination he found that the mineral differed in its chemical composition from any of the species given in Prof. Dana's group of the Margarophyllites, and notably in containing a greater amount of water as a basic element than any of them. I therefore proposed to Mr. Hannay that we should name the new mineral Bowlingite, after the locality so well known for its zeolitic minerals, and to this Mr. Hannay agreed, especially as there was a mineral of the group already named Hydrophite, which came nearer than any other to Bowlingite in the amount of contained water—the former having 16·08 and the latter 22·70.

Mr. Hannay sent a short description of Bowlingite to the "Mineralogical Magazine," in July, 1877, giving analyses of specimens from Bowling Quarry and from Cathkin Quarry, as follows:—

	Bowling.		Cathkin.		Average.
	I.	II.	I.	II.	
$Si\,O_2$	34·32	35·08	35·66	35·82	35·22
Al_2O_3	18·07	16·85	15·09	16·14	16·54
Fe_2O_3	3·65	3·92	5·22	4·85	4·41
$Fe\,O$	6·81	6·95	7·02	6·99	6·94
$Mg\,O$	9·57	10·22	12·41	11·73	10·98
$Ca\,Co_3$	5·14	4·89	5·02	4·87	4·98
H_2O	22·70	21·85	19·89	19·63	21·01
	100·26	99·76	100·31	100·03	100·08

Mr. Hannay says that the Bowlingite from both of the above localities "is a very soft mineral, having a steatitic feeling, and easily ground by the teeth without the slightest gritty feeling. Both specimens have a dark green colour when in mass, and a light

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arsenic-green colour when pulverised. Owing to its steatitic character, it cakes when ground, and has a micaceous lustre, which slightly masks its colour, and gives it a greyish tint. Its specific gravity is low, varying from 2·282 (Cathkin) to 2·292 (Bowling). It is easily decomposed by boiling in dilute acids, especially hydrochloric and sulphuric, all the bases going into solution, and the silica being left in a state only to be described as between gelatinous and slimy. As the mineral contains much water, it yields that substance when heated in a tube. The small crystals viewed under the microscope have a yellowish-green colour, and are quite transparent, a property not to be expected by the appearance of the mineral when seen in mass. The small proportion of carbonate of lime the mineral contains seems to be essential to it, as even the purest specimens contained about as much as the most troubled parts. Both alkalies and fluorine were carefully tested for, but neither were found."

Bowlingite falls to be arranged with the Serpentine group of Professor Dana's Margarophyllite section of minerals, and like many others in this group it is clearly a product of alteration of the Olivine Basalt in which it occurs. Mr. Samuel Allport, F.G.S., describes the microscopic mineral structure and composition of the rock in the Bowling Quarry, as follows:—(*On the Microscopic Structure and Composition of British Carboniferous Dolerites.* Trans. Geol. Soc., Lond., vol. xxx., p. 558)—"At Bowling, on the north bank of the Clyde, three miles east of Dumbarton, the rock forming the 'Hill of Dun' is a coarse crystalline Dolerite, varying in colour from brownish-black to black, with distinct crystals of Augite, Olivine, and Felspar disseminated through it. The porphyritic structure is well seen in thin sections. The base is rather finely crystalline, and consists of small crystals or grains of the above-mentioned constituents, together with numerous grains of Magnetite. The large crystals of Plagioclase are clear and beautifully striated; they frequently contain glass cavities, and here and there portions of the base have been enclosed in them . . . . . This rock affords excellent examples of serpentinous pseudomorphs after Olivine, in various stages of formation; the crystalline forms are wonderfully perfect, and the gradual encroachment of the serpentinous matter on the clear Olivine may be very well seen. In one of the sections—microscopic—an old fracture has been filled with Serpentine, a vein which traverses some

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of the large Felspar crystals and the surrounding base thus being formed. A few cavities are also filled with the same substance."

Having secured a large number of specimens of Bowlingite, I have been able to trace the gradual alteration of the rock into the mineral in the most satisfactory manner, there being no doubt that Bowlingite is the result of a hydrous alteration of the Dolerite along the walls of the fissure, and that it is not a mineral introduced by infiltration. The first change observable in the rock from its normal dark colour is seen in its passage gradually into a greenish-grey, with many of the Olivine crystals partly decomposed, while others have been altered into peroxide of iron of a reddish-brown colour. As the alteration of the rock goes on, the green colour deepens, and its crystalline structure disappears, while it becomes so soft that it can be cut with a knife. The next change is into the Bowlingite, with its deep green colour, and which is now so soft that it can easily be scratched with the finger nail. Most of the specimens from Bowling have a compact waxy structure; some few, however, shows a minute fibrous crystalline structure; while one specimen has a crystalline foliated structure like Mica. Amongst the specimens of Bowlingite it is not an uncommon thing to find an embedded crystal of Olivine in a partly unaltered condition, and I think that the amount of Magnesia present in the mineral is due to the abundance of the Olivine element in the rock. I also think that Olivine, from its readiness during the alteration of the Dolerite to pass into peroxide of iron, shows that it must belong to that variety termed Hyalosiderite, in which the amount of iron present is greatly in excess of that found in the typical Olivine crystals.

On a former as well as on a recent visit to the Bowling Quarry, I noticed the interesting fact that specimens of Bowlingite obtained fresh from fissures of the Dolerite in the quarry had a bright leek-green colour when broken newly across, and that this colour darkened into a blackish-green on exposure. I also found that wherever the mineral was traversed by minute cracks the bright green colour was almost always darkened on either side of the cracks. I am not able to explain the cause of this rapid alteration in colour, except that it may be due to some change of the iron elements in the mineral through exposure to atmospheric action. I have cut some pieces having the brightest green colour, and found that in less than a day's exposure they had darkened

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considerably, ultimately becoming blackish-green. I have placed pieces showing the brightest-green in a corked bottle of water without in any way preserving the colour. I am now trying the effect of a coating of gum arabic, which has so far preserved the colour for a few days, but further time will be required to see whether it proves permanent.*

So far as I know, the rocks which have yielded this mineral in Western Scotland are basic Dolerites of Lower Carboniferous age, often having a Basaltic structure. I first observed it along with the late Mr. White Skipsey, a member of this Society, when visiting the Cathkin Quarry. Specimens which I placed in the hands of the late Mr. J. Wallace Young were examined by him in December, 1866 (*Transactions*, vol. ii., page 213). He there describes the Cathkin mineral as of a blackish-green colour, with a fibrous structure, and of the hardness of Talc. Only 6·30 per cent. of water was found, but he dried the specimens at 100 deg. C., which Prof. Heddle, of St. Andrews, tells me should not have been done, as at such a heat two-thirds of the basic water, which is an essential of the mineral, were lost. Mr. Hannay, who has analysed a portion of the same specimen as that used by Mr. Wallace Young, says, that after drying it at 105 deg. C., until it lost no further weight, he still found 10 per cent. of moisture present—that being about half of the normal amount of water present in the mineral. Mr. Hannay has also found that in his analysis the other constituents differed from those given by Mr. Wallace Young, as will be seen from a comparison of the two results, which I have placed side by side:—

Bowlingite (Cathkin). J. W. Young.		Bowlingite (Cathkin). J. B. Hannay.	
Silicic acid,	31·95	SiO_2,	35·66
Alumina,	15·40	Al_2O_3,	15·09
Ferrous oxide,	21·40	Fe_2O_3,	5·22
Magnesia,	20·95	FeO,	7·02
Water (by difference),	6·30	MgO,	12·41
Carbonate of lime,	4·30	$CaCo_2$,	5·02
		H_2O,	19·89
	100·00		100·31

* NOTE.—Since the above remarks were communicated to the Society—a year ago—I find that the specimens coated with gum-arabic have gradually darkened in colour. It is, therefore, evident that such a coating has only the power of preserving the colour for a short time.

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As formerly stated, this mineral is evidently derived from an alteration of the Dolerite. Where it varies in the proportion of its constituent mineral elements, between one tract of country and another, as well as from the amount of hydrous change which it has undergone, we may therefore expect that there will be slightly varying differences in its chemical composition. I have no doubt that it will be found occurring in crusts of various thicknesses, in fissures of the Dolerites at many localities where it has not yet been noted.

XIV.—Australian Gold-Quartz in Scotland. By W. Lauder Lindsay, M.D., F.R.S.E., F.L.S.

[Read 7th March, 1878.]

I am sure that the members of the Geological Society of Glasgow would rejoice with me could it be proved that there is auriferous quartz, *in situ*, in Scotland: that they will agree with me in the desirability of our national museums possessing proper illustrative suites of the golds and gold-rocks of our native country: and that they will be sorry with me that Scotland should take or get credit for golds or gold-rocks that may not really belong to her. This being the case, I venture to ask your attention to the curious history of two finds of gold-quartz recently made in the area of which Glasgow is the natural centre—viz., at Wanlockhead, Dumfriesshire, on the one hand, and at Rothesay, in Bute, on the other. The specimens referred to are now exhibited in public museums, and can therefore be inspected by any of those who hear or read these words of mine, while the circumstances under which they were discovered can readily be investigated on the spot by those of you who will give the necessary time and application to so interesting an inquiry. In both cases the museum exhibits to which I refer have been the subject of hot, and even acrimonious, newspaper controversy, the real point at issue, however, being, not whether they were found at Wanlockhead and Rothesay respectively, but whether, though found there, they belong to, or represent, the rocks of these districts. It has been alleged, on the one hand, that they are, and must be native, simply because they have not been proved to be foreign. Nor can it be *proved* either that they are native or

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foreign. But there is presumptive evidence in favour, I think, of their foreign origin—of their being, in fact, Australian; and it is to the nature of this presumptive evidence that I desire to call your attention, in order that further inquiry may be made, and the nativity, probable or certain, of these doubtful specimens cleared up one way or the other.

Inasmuch as the present paper is intended merely to create discussion among those competent to throw additional light on a puzzling subject; to stimulate to inquiry, and to seek for information; not to support my own views, but for the establishment of the truth, whatever it may be; I must not be expected to go into detail, as to references or quotations, in support of my assertions. Nor is this necessary, considering that I have gone into detail in no less than twenty published papers on the natural history of the gold-fields of Scotland, and though some of these papers are not accessible, others are, having appeared in such Transactions as those of the sister Geological Societies of Edinburgh and Dublin, or in such serials as the "Scottish Naturalist." It is desirable, however, that I should impress upon you the fact that, if the specimens of gold-quartz referred to can be accepted as really Scottish—as pieces of auriferous quartz from veins still to be found in the Lower Silurians of the Lowthers and of Bute, these museum exhibits are of the highest value as unique samples of native Scottish gold-quartz. And the significance of this circumstance can only be appreciated by the consideration that, notwithstanding all the gold mining in Scotland in the sixteenth and seventeenth centuries, of which we may daily expect an authentic account from Mr. Cochran-Patrick, of Woodside, Beith,* the author of "Records of the Coinage of Scotland," there is not to be found in any of our museums or mineral collections a single specimen of gold-quartz, of any size, which can be proved to be a native of Scotland, nor is there any record, that can be depended upon, of the finding of auriferous quartz *in situ* in Scotland. On the other hand, it has to be borne in mind that while Scottish gold and gold-quartz is most meagrely represented in our public museums, Australian gold-quartz is superabundant. It is to be found in every museum, almost in every private house. It is carried in the loosest possible way about the country, and, as a consequence,

* Since published (in 1878).

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specimens of it are constantly being lost and found in the most unexpected localities and under the most unexpected circumstances. It is highly desirable that those members of your society who have had experience of such losses and finds of Australian gold-quartz specimens in Scotland should place on record somewhere, so as to be accessible, the circumstances of their individual experience.

Without further preamble let me now introduce the immediate subjects of criticism—two specimens of gold-quartz, one in the Museum of Science and Art, Edinburgh, the other in the Museum of the Archæological and Physical Society of Bute, at Rothesay.

The first-named specimen (by far the more important of the two) bears the following printed label:—"Auriferous Quartz.—Found by A. Gemmell, miner, at Wanlockhead, in 1872. This specimen was unfortunately broken up by the finder, and the different pieces came into the possession of his Grace the Duke of Buccleuch; Mr. Clark, of Speddoch; Mr. Dudgeon, of Cargen; Dr. Grierson, Thornhill; and Mr. Stewart, Wanlockhead; who have presented the restored mass to the Museum of Science and Art, Edinburgh."

The Rothesay specimen bears on its label that it is "Bute gold, presented by Mr. Lindsay, Argyll Place" (that is Rothesay).

In the first case the presumptive evidence that the specimen is Australian and not Scottish is mainly this:—That nothing was heard or seen of it, though a lump whose weight was variously stated at from 3 to 20 lbs., till the morning after a collection of pieces of Australian gold-quartz [belonging to a miner in the village of Wanlockhead, and which had been brought from Australia by himself, or some of his brothers, who had been engaged in gold mining there] was trundled in a hand-barrow up what is known as the Landlord's Brae of Wanlockhead. It is quite inconceivable to me that the specimen could have lain where it did lie—on the side of the road up which the said collection had been trundled on the preceding evening—without having been found prior to the said evening, if it did not form part of the said Australian Collection. We have the evidence of the Rev. Dr. Porteous, of Wanlockhead, whose manse looks down upon the spot where the specimen in dispute was found, and who collected at the time all the available evidence—

(1) That it is the general belief of the inhabitants of the district that the found specimen is foreign.

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(2) That it has the characters of the Australian gold-quartz alluded to; while

(3) It has not the characters of the prevailing quartz of Wanlockhead.

And I may add here that, amidst the conflicting assertions made in the newspapers by partizans on both sides, I profess and prefer to be guided—where I am not guided by what I have myself directly seen or heard—by the published narratives of Dr. Porteous, who, with a nine years' residence in the heart of the district, ought to know the whole history of this curious gold-find, if anybody does.

The simple theory of the find constructed by Dr. Porteous, myself, and others, is that it was one of the specimens of Australian gold-quartz which was jolted or jerked out of the open barrow on its way up the Landlord's Brae, and that it was lost where it was found. That the loss was never discovered by the loser is not at all surprising, considering the number of pieces indistinguishable by head-mark, and no doubt unnumbered, that were being conveyed in the course of a "flitting" from one part of the village to another.

In order to prove that the found specimen is native and not foreign, it is necessary to show that it possesses certain qualities in common with the quartz *in situ* about Wanlockhead, and that it differs as markedly from the Australian gold-quartzes, of which at present it is presumed to be one. To demonstrate this similarity on the one hand, and difference on the other, is a feat that perhaps may be accomplished by the chemical mineralogist. On such a subject I cannot pretend to speak either as a chemist or a mineralogist proper, but I believe it to be most unlikely, indeed all but impossible, that any of our chemists or mineralogists, or all of them conjointly, can prove the gold-quartz lump found at Wanlockhead to be identical with the quartz-veins or lodes of that district, and different from the Australian gold-quartzes still to be seen in a certain house on the Landlord's Brae, within a stone's-throw of the place where the find was made.

The story of the Rothesay specimen is somewhat simpler, more obscure, and less important. I am indebted to the father of the finder for a straightforward account of the find in a letter sent to me in August, 1877. The writer has no hesitation in asserting that what his son found is native gold-quartz. But there are sundry difficulties in the way of accepting this view of the case. In the

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first place, it was stated in one of the Rothesay newspapers at the time—that is, in 1874—that a piece of Australian gold-quartz, corresponding in character to the piece found, had been dropped by a boy some days prior to the find, and near its locality. No proof was furnished of the correctness of this assertion, however. Again, my informant, who describes the gold-quartz as one of a number of "fragments of quartz that workmen had made whilst laying metal pipes for the conveyance of the sewage further seaward on the beach nearly opposite my residence"—viz., Argyll Place, Rothesay—says that he himself collected on the same spot a number of other pieces of quartz, "and found them to agree in all respects with the specimen referred to." But he, on his part, furnishes no evidence that these other "fragments agreed in all respects" with that first found, for instance in the essential respect of containing gold. And, lastly, just as in the Wanlockhead case there is no such thing as a genuine piece of Wanlockhead gold-quartz with which to compare the pretender, so there is no such thing as a genuine sample of Bute gold-quartz with which to compare this Rothesay find. On the other hand, in both cases the specimens found have at least the common naked-eye characters of hosts of samples of common Australian gold-quartz.

XV.—Notes *on the* Varieties *of* Trap Rocks *found on the Coast of Ayrshire, near Largs.* By David Corse Glen, F.G.S.

[Read 12th April, 1878.]

While resident at Largs last summer, I felt so much interested in the series of volcanic rocks exposed along the shore, and in the boulders derived from the adjacent hills, as well as from the rocks found *in situ* along the coast, that I began to make a collection of their varieties. As these specimens present differences from those taken from the trap hills around Glasgow, I have thought that it would interest the members if I exhibited the collection, making a few remarks upon the mineral composition, and on the probable position and age of the Ayrshire volcanic rocks.

The hills of Ayrshire and Renfrewshire, lying south of the Clyde, form an extension of the great range extending from near the town of Stirling on the east to Ardrossan on the west, and which embraces in that distance the Campsie and Kilpatrick hills. A considerable amount of light has been thrown, during recent years, upon the age

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of the great group of igneous rocks which build up this extended series, due to the researches of members of this Society, and to the progress of the Geological Survey. It has now been clearly shown that the age of the great lava flows, building up these hills, belongs to the upper division of the calciferous sandstone series of the Scottish Carboniferous formation. The basement rocks of this range consist of red sandstones and conglomerates formerly grouped under Old Red Sandstone, but now placed amongst the Lower Carboniferous rocks by the officers of the Survey. These sandstones are succeeded upwards by an apparently conformable group of thin-bedded limestones and marly shales (the cement limestones of the Geological Survey), which are well displayed at the Spout of Ballagan, and at other points along the base of the Campsie, Kilpatrick, and Renfrewshire hills. The sandstones and limestones with the bedded traps thus form the calciferous sandstone series or Lower Carboniferous strata of Western Scotland. Subsequent to the deposition of the cement limestone group this series of strata, along with the underlying red sandstone, had, it is evident, suffered considerable denudation over the district, before the lowest sheets of traps were poured over the surface. At some points of the Ayrshire and Renfrewshire ranges the trap rests in one case on the red sandstone, and at other places on the denuded surface of the cement limestones; and wherever the junction of the igneous and stratified rocks is seen, the latter are always considerably indurated by heat derived from the former. Previous to the deposition of the Carboniferous limestone series, this great group of contemporaneous igneous rocks must have covered an extensive tract of country in Western Scotland. Everywhere we find the limestone series resting in basins of the trap, the latter coming to the surface of the country, either along the lines of great faults, or where the limestone strata have been denuded away from its surface. The manner in which the calciferous traps are again and again brought to light through the agency of faults, and by subsequent denudation, is very clearly displayed in the various sheets and horizontal sections of the Geological Survey which illustrate the Western Scottish coal-fields. There is clear evidence to show that the great sheets of trap which border and hem in the several coal-fields in the before-mentioned tract of country are of calciferous sandstone age. Volcanic action did not, however, altogether cease with that period of time. In the

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Carboniferous limestones of the Ayrshire coal-field, beds of contemporaneous volcanic ash and dolerite are met with in several localities, while we know that other masses of igneous rocks, in the shape of necks of agglomerate, dykes and intrusions of basalt and dolerite, are referred to the Permian and Middle Tertiary periods.

I shall now shortly point out the mineral character of the several lava flows. From the researches which have been made of late years into the microscopic structure and mineral composition of the volcanic rocks of this country by various able investigators, we now know much more than we used to do of the structure and composition of this class of rocks. It is now shown that the Scottish volcanic rocks may all be referred to two classes—an acid group and a basic group—the former rich, the latter poor, in silica. This theory was first brought forward by Durocher in his "Memoir on Comparative Petrology," and it has now been adopted by Prof. Haughton in his "Manual of Geology," and also by Prof. J. W. Judd, F.G.S., in his valuable papers "On the Secondary Rocks of Scotland and the ancient Volcanoes of the Highlands," published in the Quarterly Journal of the Geological Society of London, in 1874. The latter author gives the two following tables, which show clearly the average ultimate chemical composition of the igneous rocks of the acid and basic series. Under the former he classes granite, syenite-granite, felsite, felstone, and pitchstone; and under the latter, gabbro, augitic gabbro, dolerite, basalt, and tachylite, giving in each case the specific gravity, and the amounts of silica, alumina, potash, soda, lime, magnesia, and manganese, in their maximum, average, and minimum proportions.

Q. J. Geol. Soc., Vol. XXX., page 234.

	Acid Series.			Basic Series.		
	Max.	Average.	Min.	Max.	Average.	Min.
Silica, . . .	80	72	61	55	50	45
Alumina, . .	19	15	10	18	14·5	10
Alkalies, . .	20	7	0	8	3·5	0·5
Alkaline Earths, .	8	2	0	29	17	8
Oxides of Iron and Manganese, .	5	2·5	0	19	14	8

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TABLE

Illustrating the Average Ultimate Chemical Composition of the Igneous Rocks of the Acid and Basic Series.

Prof. J. W. Judd, "Q. J. Geol. Soc.," Vol. XXX., page 235.

	Specific Gravity.			Silica.			Alumina.			Potash.			Soda.			Lime.			Magnesia.			Oxides of Iron and Manganese.		
	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.	Min.
Acid Series.																								
Granite, . . .	2·73	2·66	2·60	78	72·8	66	18	15·3	11	9	6·4	4·	2·5	1·4	0·	1·5	0·7	0·	2·	0·9	0·	2·5	1·7	0·5
Syenite-granite,	2·75	2·68	2·63	72	69·0	64	17	15·0	12	6	4·2	3·	3·5	2·8	1·	4·	2·2	1·	4·	2·6	2·	5·	3·2	2·
Felsite, . . .	2·70	2·65	2·60	81	74·3	68	15	13·1	11	8	4·4	2·	5·	2·8	0·5	3·	1·2	0·5	1·5	0·6	0·	5·	2·8	1·
Felstone, . .	2·68	2·64	2·58	80	75·4	68	18	15·0	11	6	3·1	2·	6·	1·3	0·	2·	0·8	0·	2·5	1·1	0·	4·5	2·3	0·5
Pitchstone, &c.,	2·36	2·34	2·31	74	70·6	62	17	15·0	11	6	1·6	0·	3·	2·4	1·5	1·5	1·2	1·	2·	0·6	0·	4·	2·6	1·
Basic Series.																								
Gabbro, . . .	3·10	2·95	2·85	54	49·0	45	17	15·0	12	1	0·3	0·	4·	2·5	0·5	14	9·5	6·	15	9·7	7·	14	11·5	8
Augitic-Gabbro,	3·90	2·90	2·75	54	49·8	45	20	16·5	14	3	1·7	0·8	6·	3·9	2·	11	7·9	4·5	7	5·4	4·	16	13·0	8
Dolerite, . .	3·10	2·95	2·85	55	51·0	45	16	14·0	12	1	0·2	0·	5·	3·4	2·	13	10·0	7·	9	5·5	3·	18	14·7	9
Basalt, . . .	3·10	2·96	2·85	53	48·	42	18	13·8	10	3	1·5	0·5	5·	3·0	2·	14	10·	7·	10	6·5	3·	16	13·8	9
Tachylite, . .	2·54	2·52	2·50	56	54·3	50	18	16·0	12	4	1·8	0·5	5·	4·0	3·	8	7·2	6·	6	2·8	0·5	13	11·2	10

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It must be remembered, however, that between the two groups—acid and basic—there is another series of igneous rocks less rich in silica than the typical acid group, and poorer in pyroxenic minerals—such as augite and olivine—than the basic group; and to the series having this middle chemical composition the term "Intermediate Group" is sometimes applied. It may be noticed from the table that the specific gravity of the basic group is greater than

Green's Geology, 1878, page 49.

	Specific Gravity.	Silica.	Alumina.	Soda and Potash.	Lime and Magnesia.	Oxides of Iron and Manganese.	Water, &c.
Acid Rocks,	2·5	74	12	7	2	3	2
Intermediate Rocks,	2·4	58	17	8	8	7	2
Basic Rocks,	2·9	49	17	4	15	13	2

that of the acid group, and from this fact it is supposed that all rocks classed under the former group have been ejected from a fluid magma lying at a greater depth within the earth's crust than that from which the latter group of rocks were erupted; the two magmas holding the same relation to each other that the lighter slag does to the heavier iron in the blast furnace. A comparison of the varieties of bedded traps from the Ayrshire hills, which bound the coast near Largs, with those of the Renfrewshire hills nearer Glasgow, and with those of the Kilpatrick and Campsie ranges north of the Clyde, seems to show that, in the former, the acid group of minerals prevails to a larger extent than in the traps of the last mentioned hills, in which some of the lava flows, belonging to the basic group, largely predominate. As far, therefore, as my observation goes, I am inclined to think that fewer of the basic traps occur in the south-western portion of the range than in the north-eastern division. Time did not permit of my making an examination of the several lava flows which build up the hills near Largs, for the purpose of seeing whether the several sheets which form the terraces on their north-western faces differ much from each other when examined in ascending order. This would be an interesting point to ascertain, and I hope to have a future opportunity of doing so.

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It has been stated by Prof. Judd, in his papers already referred to, where he treats of the ancient volcanoes of the Highlands, that, during the periods of great volcanic activity in Scotland, the earlier flows of lava were, as a rule, generally of the acid group, whilst those poured out at the close of the period belonged more to the basic group; so possibly a careful examination of the several beds of trap in the Ayrshire hills would show whether over this tract of country, and in the period represented by these lava flows, there has been any change in the mineral elements, showing a passage upwards from felstones into dolerites, or whether in some instances the two groups may not alternate with each other. As previously stated, the bedded traps of the Largs portion of the Ayrshire hills chiefly belong to the acid series, consisting of many varieties of felstones, which vary in texture and colour from compact felstone to porphyritic felstone and amygdaloidal felstone. The numerous varieties which these rocks have yielded do not depend so much upon any change in the mineral composition of the several lava flows, as on the rate at which the igneous matter cooled, and the amount of aqueous vapour present. Where the cooling process has been slow a porphyritic crystalline structure has been the result, and where aqueous vapour has been present, the rock has taken a vesicular character, from the expansion of the vapour within the cavities. These cavities are often found filled by a subsequent infiltration of various mineral elements, such as silica, calcite, and the various zeolitic minerals, the rock then becoming what is termed an amygdaloid. I have noticed that, as a rule, amygdaloidal structure is more common amongst the felspathic or acid rocks than amongst the doleritic or basic group. This fact would seem to imply that the former has often more aqueous vapour locked up amongst its mineral elements, than that of the deeper seated basic lavas. Another point worthy of notice is that many of the felstones of this range of hills have a reddish, and sometimes a decidedly red, tinge of colour, much more so than the traps of the north-eastern portion of the range. This colour is apparently owing to the presence of peroxide of iron in the rock, and also to the complete oxidisation of the iron elements. I have already stated that the traps of this tract of the Ayrshire hills seem to belong chiefly to the acid group or felspathic series; yet the basic group is not wanting in this district, as well as in other parts of the Ayrshire coal-field, in the form both of intrusive sheets and dykes of dolerite, the latter

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being well exposed on the coast between Largs and Fairlie, in a series of interesting dykes which cut the red sandstone along the shore. These dolerite dykes are apparently closely allied in mineral composition to those seen coming through the red sandstone on the Ascog shore in Bute, and are probably of the same age, belonging to the Miocene volcanic rocks of Western Scotland. Necks of volcanic agglomerate, tuff and other varieties of trap also occur in other parts of the range, and are believed to be of Permian age. They are seemingly the last dying efforts of the great palæozoic volcanoes of Western Scotland, to the long-continued action of which the formation of this extended range of hills is due.

I have now said enough to point out in a general way the chief mineral characters of these rocks. The charm which their physical features have impressed on the scenery around is so well known and generally admired that, independently of their mineral composition and of the great interest attached to their origin, their investigation will, I hope, always form an instructive field of study for the young geologist, as it has been to myself. If the foregoing notes should induce any member of the society, who may have the chance of spending a few days at Largs, to look at the assemblage of trap rocks found on that coast with a more appreciative eye; and if, further, they should induce some one to take up the study of the petrology of the district, then any trouble I may have had in writing them or in forming my collection will have been amply repaid.

XVI.—Recent Discoveries *among the* Silurians *of South Scotland.* By Charles Lapworth, F.G.S., St. Andrews.

[Read 26th April, 1878.]

[Summary.]

No sooner were these ancient strata studied in earnest by geologists, instructed by the world-renowned achievements of Murchison in Siluria, than what appeared to be clear and unmistakable proofs of a definite sequence were discovered. The earlier investigators soon recognized the fact that, when viewed upon a large scale, they dipped apparently N. and S. from an axial line running from Berwick to Dumfries. In the neighbourhood of

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this line they had a very ancient appearance, reminding the geologist of the strata of the Longmynd, which, in Siluria, rise out from below the base of the Silurian system. A further resemblance was found in the fact that they were similarly destitute of all traces of organic life. Precisely as in Siluria, the rocks which surmounted these barren beds in the south of Scotland were found to contain an abundance of the little understood fossils known as graptolites. These graptolite-bearing strata were subsequently ascertained to form the floor of the whole of the Uplands to the north of the unfossiliferous beds, except near the town of Girvan in Ayrshire. There certain limestones and schists were discovered, crowded with fossils, the majority of which were identical with those of the Caradoc formation of Wales, which was known to succeed the great graptolite-bearing Llandeilo formation of that country. To the north of these Girvan beds, higher Silurians were detected in the Pentland Hills and at Lesmahagow, crowded with Upper Silurian fossils, and passing upwards into rocks belonging to the succeeding system of the Old Red Sandstone. To the south of the axial line similar Upper Silurian rocks were discovered near Kirkcudbright.

At this point the officers of the Geological Survey commenced their investigations. Adopting the conclusions of their predecessors that the axial rocks were the oldest strata of the south of Scotland, that the graptolite-bearing strata were of Llandeilo age, and that the Girvan beds succeeded them in natural sequence and were of Caradoc age, they greatly extended this theory of succession by subsequent discovery and speculation. In the Girvan district a remarkable zone of crystalline and metamorphic rocks was detected which appeared to have undergone regional metamorphism, and its alteration was attributed to hydrothermal agency. The great mass of the graptolite-bearing rocks were divided by the officers of the Survey into several successive zones, and were estimated as having a collective thickness of about five miles. Discovering among these Llandeilo rocks certain conglomerates resembling those of Girvan and containing similar fossils, they held that the Caradoc or Girvan rocks lay unconformably upon the graptolite-bearing rocks below. Later on they were compelled to recognize the existence of Upper Silurian strata of Wenlock age, at no great distance south of the axial line, and they accounted for this fact on the theory of a general unconformity between the Lower

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and Upper Silurians. In 1873, the director of the Survey announced that the geological structure of the Uplands was at last unravelled, and the order of succession established. At the base he placed the axial rocks, which, with all the overlying graptolite-bearing rocks, were regarded as of Llandeilo age. They were supposed to be followed unconformably by the Girvan beds, which were finally succeeded by the great unconformable mass of the Upper Silurian.

After pointing out how naturally this theory of succession had been evolved, and how well grounded it appeared to be to those who took broad views of apparent superposition and disregarded minute palæontological difficulties, the author showed upon what slight foundations it rested. Its most strenuous advocates all admit, that in any single section it is almost, or quite, impossible to say whether we are ascending or descending in the order of the beds. Little or no reliance can therefore be placed upon the stratigraphical evidences upon which this theory leans. The graptolites by no means prove the Llandeilo age of the rocks which contain them, for the majority of the forms are of Caradoc or later age. There is no physical evidence that the Caradoc conglomerates are uncomformable upon the graptolite-bearing beds.

If we accept this theory of the succession, we have to admit that the Upper Llandeilo of South Scotland is as thick as the whole of the Lower Silurian of every other country yet examined by geologists; and if the order of the beds adopted by the Survey be correct, the fossils in the various horizons make their appearance in the inverse order to that which they follow in Siluria. If the graptolite-bearing strata are of Llandeilo age they should contain some evidence of contemporaneous volcanic rocks, for at this period there were enormous active volcanoes in the Lake District, only a few miles to the southward.

The discoveries made of late years by the author enable him to propose a new theory of the succession, which is in consonance both with the stratigraphical and palæontographical evidences, and brings the South Scottish Silurians into perfect harmony with those of other countries. The district which has yielded the most conclusive proofs of the true sequence lies in the neighbourhood of Moffat. At the head of Moffatdale, a deep gorge known as Dobb's Linn affords a magnificent section of the black graptolite shales. The author showed that the black shales of this spot are arranged in an anticlinal form and come out conformably from below the

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greywackès of the district. These black shales fall into the three natural divisions denominated the Glenkiln, Hartfell, and Birkhill shales. Each of these three divisions contains a special graptolite fauna of its own, and breaks up again into many subordinate zones, individualized by special mineralogical and palæontological distinctions. It was explained that this section gives us the key to the geological structure of the district. All the black shales of the neighbourhood are found to rise in arches from below the greywackès and to show the same divisions, zones, and fossils as at Dobb's Linn. This group of graptolite shales (which is termed the Moffat series) is unique among Scottish formations in the rapid change which takes place among its fossils; for the whole formation is only about 300 feet in thickness in the typical localities, and each fossil ranges through a fraction only of that extent. The author showed that the fossils of the Glenkiln division are those of the very highest beds of the Llandeilo of Wales, Sweden, and America. Those of the Hartfell division are known in the Bala beds of Conway, Scandinavia, and New York. Those of the Birkhill shales are all found in the Lower Llandovery of Westmoreland, Thuringia, Sweden, Brittany, &c. It was contended that these results proved that the three divisions of the Moffat series represented the highest Llandeilo, the Bala, and the Lower Llandovery of Wales, respectively, and that the similarity of the succession of forms in the countries cited demonstrated the correctness of the author's reading of the structure of the Moffat area.

The excessive thinness of the three formations in Moffat was shown to agree precisely with the facts known in Britain and Scandinavia; and it was argued that the Moffat series were simply British Silurians of the Scandinavian type.

The black shales are by no means confined to the Moffat district but rise again and again to the surface to the north and west. It was shown by a comparison of their fossils with those yielded by the Moffat series, that all these black shales are clearly repetitions of those of the Moffat district; and proofs were adduced to show that they generally rose out from below the barren greywackès in anticlinal forms. It follows, therefore, that the whole of these greywackès from St. Abb's Head to the Mull of Galloway must be as young as, or younger than the Moffat series, and that the vast majority of them are of Upper Llandovery age.

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It was pointed out how perfectly this conclusion harmonises with what is known of the few fossils they yield, and how it not only rids us of the necessity of the supposed great anticlinal line between Berwick and Dumfries, but also does away with the hypothetical unconformabilities at the base of the Caradoc and the commencement of the Upper Silurian.

The black shales of the Moffat district retain their special peculiarities with great uniformity when followed along the line of strike (N.E. to S.W.) So remarkably is this the case, that we know of minute seams of a few feet, or even an inch or two in thickness, which remain without any appreciable alteration along a line extending over three or four counties. Some even retain their distinctive features, their comparative thickness, their general mineralogical characteristics, even the slight peculiarities of the matrix, and the state of preservation of the fossils, far into the interior of the North of Ireland.

The case, however, is vastly different when the strata are followed in the direction of the dip. The Upper Birkhill beds of Dobb's Linn consist of black fossiliferous seams imbedded in a mass of grey shales. Immediately we pass to the north of this locality the change begins. The black shales gradually die out, and the grey rocks thicken. Six miles to the north of Dobb's Linn nearly all the black shales have vanished from the highest Birkhill beds, which have become a sheet of barren grey flagstone and shales, precisely identical with those intercalated among the greywackès of the country. The same rule holds good throughout the whole of the south Scottish Silurians. The greywackè zones sink deeper and deeper into the Moffat series as we pass over them to the north-west. First, the Upper Birkhill black beds disappear, as at Drumbredden; next, the Lower Birkhill, as near Dalry; next, the Upper Hartfell, as in the Moorfoots and Leadhills; and lastly, the Lower Hartfell and Glenkiln shales, as in the Girvan district.

The grey beds, which thus replace the typical Moffat series, though resembling in many of their essential features the wide-spreading sheet of greywackès of post-Moffat age, are, however, by no means of so monotonous and homogeneous a type, when regarded in their collective aspect. They include thick beds of pale shales, grey, yellow, and green mud-stones, sheets of breccia, conglomerate, and massive beds of limestone. The whole series

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thickens to the north-west; the barren flagstones, breccias, &c., coming in one after the other in the dark shales, replacing and expanding each bed in its turn. Occasionally however, a black seam remains unaltered, and these survivals, and their representatives found here and there in the greatly expanded mass of beds, enable us to parallel them almost zone for zone, with the contracted, but much more easily understood succession among the shales of the Moffat district.

As might have been inferred from these facts, the lowest formations of South Scotland attained their grandest expansion and most varied features in the Girvan district, the area geographically the most removed from the Moffat district.

In the Girvan area the lowest rocks seen are masses of metamorphic strata—shales, grits, and conglomerates—associated with, and pierced by, volcanic rocks of the most varied character. These constitute the *Ballantrae Rocks*—a most remarkable assemblage, and one whose sequence and relationships it will need years of patient study to unravel.

The Ballantrae Rocks are surmounted by the conglomeratic group of *Barr*. The chief member of this series is the massive conglomerate of Kennedy's Pass—the grandest mass of silurian conglomerate known to geologists. It is derived apparently in part from fragments of the underlying Ballantrae Rocks and in part from metamorphic rocks not now visible in South Scotland. Near its base it contains the *Craighead* or *Aldons* limestone, which is crowded with fossils of the general type of those of the *Trenton* beds of North America. At its summit are the *Balcletchie* seams of shale and conglomerate, full of characteristic Trenton forms.

Above the Barr group we meet with the *Ardmillan or Ardwell* group of shales and flagstones, of great thickness—crowded in the black seams with the Graptolites of the Hartfell shales, and in the more calcareous beds (especially in the *Drummuck* shales at its summit), with swarms of fossils similar to those of the Bala series of Wales, the Cincinnati group of North America, and the Trinucleus beds of Scandinavia.

The Llandovery beds of Wales are here represented by the strata denominated by the author, the *Penkill* Group. The basement beds of this group are the *Mulloch Hill* sandstones and conglomerates. The central beds are the *Saugh Hill* sandstones and shales, and the *Pentamerus* limestones of *Penwhapple Glen*. The

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highest zones are the *Crossopodia* shales (Thornilee beds) and the *Retiolites* or *Priodon* flags (Gala group) of Penkill.

The Mulloch Hill beds appear to represent the Brachiopod-schists of Sweden. The calcareous Saugh Hill and Pentamerus beds are crowded with *Pentamerus*, *Favosites*, *Petraia*, and other so-called Upper Silurian forms. Their black beds afford the Birkhill Graptolites. The purple and gray Crossopodia shales and flags come into the place of the Tarannon beds of Wales.

Outside the Girvan district proper, the Priodon or highest Penkill beds pass upwards into the Straiton group of thin bedded flagstones and shales, affording acknowledged Wenlock Mollusca, and Graptolites. These beds resemble the Hawick rocks in their lithological characters and occupy a corresponding palæontological and stratigraphical horizon.

The Straiton flags pass up into the Lesmahagow series, whose lowest beds are absolutely undistinguishable from the Riccarton flags. Their highest strata swarm with the well-known Eurypterida of Lesmahagow, and are believed to graduate upwards into the basement beds of the Old Red Sandstone of the Valley of the Clyde.

XVII.—Craignethan *and its* Vicinity. By John R. S. Hunter, LL.D., D.Sc., Fellow of the Royal Physical Society of Edinburgh, Fellow of the Edinburgh Geological Society, Corresponding Member.

[Read 24th May, 1878.]

The parish of Lesmahagow is situated in one of the most picturesque districts of Scotland—one rendered famous by the Falls of Clyde; the lofty and rugged Crags of Cartland, with the new and old bridges; Tinto, the hill of fire, the ancient beacon of the Upper Ward; the Lee Valley, where still stands a noble remnant of the ancient Caledonian forest, known now by the name of the Peas Tree; also Hallbar, the Tower and Fortalice of Braidwood, with its massive walls, six feet in thickness. This parish formed a portion of the Roman province of Valentia, and afterwards of the British Kingdom of Strathclyde, until that kingdom, in the ninth century, became incorporated with those of the Scots and Picts. In many of the deep glens of the district Sir William Wallace

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no doubt found frequent shelter. At Gillbank (or Kilbank) he frequently was the guest of his friend Auchinleck. In the adjoining parish of Carluke, at "Forest Kirk," the hero was chosen Guardian of Scotland. In the neighbourhood may still be seen the sites of ancient structures, which remind us of the olden time, "when mailed warriors grimly smiled on the unfurled banner, as the points of a thousand Clydesdale spears glittered in the sun." In fancy we still hear the towers resound with the din and clash of arms.

Craignethan, or Nethane, Castle—variously written Craignithane, Nauthane, Nathane—is also styled Draffin, Draffane, or Draphan Castle, but is better known now as Tillietudlem Castle. With the exception of notices of transmissions of the property, I have not found any historical events connected with Craignethan Castle earlier than towards the end of the reign of James V. The Hamiltons were then a powerful family in Lanarkshire, but Sir James Hamilton of Finnart, who built the castle, was not in possession of lands in Lesmahagow earlier than 1532, and it is possible that the castle did not exist till after that date, and prior to 1538; in which year a charter was granted to the castle and lands, and this is the first time the castle is spoken of.

In 1532 we find a charter connecting Sir James Hamilton of Finnart with Lesmahagow, and another charter in 1538 granting "Castre de Nauthane et terrarum ejusdem," &c.

The Castle of Nethane, Craignethan, or Tillietudlem, is believed to be a reconstruction, and very probably it was the site of a former dwelling-house or chapel.

From all we find recorded of Sir James Hamilton, he was undoubtedly a man of great talent and energy, and acquired great power and influence at the court of James V. He was the natural son of the first Earl of Arran and a daughter of Lord Boyd, or of Boyd of Bonshaw, in Renfrewshire. The date of his birth has not been discovered, but a charter to Finnart, in his favour, by his father, is dated 3rd November, 1507, and a deed of legitimation passed the Great Seal on 20th January, 1512.

On 22nd May, 1527, Sir James was appointed Captain of Dumbarton Castle, and held the office for nine years. In 1536 he was Cup-bearer and Steward to the Royal Household of King James V., and, no doubt, was with the King on his memorable voyage, which he undertook to get in marriage the Princess Magdalene of France. He

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shipped at Leith, but instead of landing in France, a storm arose and drove the ship to the west shores of Scotland. Sir James was suspected of being instrumental in misguiding the ship, and thwarting the designs of the King; in such circumstances the kindly feeling between them was not greatly cemented. Sir James had now extensive estates in Lanarkshire and elsewhere, and maintained a retinue equal to the first baron of the land. King James V. paid a visit to Craignethan in 1540, to assist at the marriage of Sir James's daughter, Agnes, with James, Master of Somerville, Carnwath. Not long after this, Sir James Hamilton fell into bad grace with his Majesty, and his estates being forfeited became vested in the Crown, while David Orrok was made keeper of the castle.

From Sir James Hamilton's position with the King, it is probable that much of his wealth was conferred on him by that monarch, and there is a charge in the Memorials of Edinburgh Castle, which, though possibly fictitious, points to one source of wealth, viz.:—for conspiring against James V. and embezzling moneys paid to him, as Royal Architect, for the repair of Castles and Palaces. Under his auspices the Palaces of Falkland and Linlithgow were erected, and the Castles of Edinburgh, Stirling, and Rothesay were rebuilt or adorned by him.

It is not then surprising that Craignethan Castle should have been no mean proof either of the taste or resources of its owners. It may be briefly described as occupying the summit of a promontory, high above the river Nethan. Its enclosures form a parallelogram, the outer walls being of considerable height and thickness, with a gallery or platform extending along the top, while the walls are loop-holed, evidently for defensive purposes. Each angle was defended by a high, square tower, and on one side there are two smaller ones. The tower on the north-east was much the largest, and within it, no doubt, part of the garrison was lodged. Within the enclosure are the remains of a broad ditch, or dry moat, which must have been crossed by a drawbridge. The arched gateway in the west face is most beautiful. At the north-east end of the inner court stands the castle itself, containing the banqueting-hall and principal apartments, the roofs of those on the ground-floor being beautifully arched. Beneath are a series of vaults, so extensive as to suggest the idea that they may have been used for storing provisions and warlike supplies, in the event of a protracted siege—some possibly having been used as dungeons for keeping

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prisoners. On the summit of the castle walls there still remain traces of an embattled parapet, with small turrets at the angles.

In 1541, James V., accompanied by his Queen, paid a visit to Craignethan Castle, no doubt to enjoy hunting, of which he was extremely fond. The Castle was then decorated by tapestry, for we find that, by the chamberlain's accounts, tapestry was taken from Crawfordjohn to this castle, and thence conveyed to Peebles and elsewhere.

When Queen Mary escaped from Lochleven, on the 2nd May, 1568, she first took refuge at Niddrie Castle, the property of Lord Seton in Linlithgowshire, and arrived at Hamilton on the 4th of May, and for better security took up her residence at Craignethan Castle, whilst her friends and adherents were assembling from all quarters with the Hamiltons. Sir James joined the Queen's party, and signed the bond of defence, 8th May, 1568. He led the vanguard of the Queen's forces, and was, along with his son, taken prisoner at the battle of Langside. After the defeat there, the Regent Murray made an expedition northwards, at the head of a large force, and took the Castle of Draffane and Palace of Hamilton.

From the Earl of Arran's insanity, his younger brothers, Lord John Hamilton and Lord Claud Hamilton, were regarded as the leaders of their powerful and ancient family—Lord John being in possession of the estates, while, in the event of the death of Queen Mary and her son, he was heir to the throne of Scotland. The Regent Morton had long looked upon the Hamiltons with displeasure, and as his possession of the person of the young King enabled him to overawe him and fix his councils, the destruction of the Hamilton family was determined upon, and at that troubled period reasons were not long wanting for this decision. King James VI. issued a commission to John Earl of Morton, Archibald Earl of Angus and others, dated at Stirling, 22nd May, 1579, and the whole of the Hamilton estates were confiscated—the most cruel and arbitrary proceedings being directed against almost all the gentlemen of the name. A party of soldiers being sent to demand the surrender of Craignethan Castle, the servants, after making what defence they could, were forced to surrender, and the Earl, along with his aged mother, the Duchess of Chatelherault, was sent to Linlithgow, and placed under the custody of Captain Lambie, a creature of Morton's, and a most inveterate enemy of the House of Hamilton, and the same mis-

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creant who insulted Queen Mary on her surrender at Carberry Hill.

By an Act of restitution, the estates of the Hamilton family, with the Castle of Draffane, were restored in 1585. In 1587, while the unfortunate Queen Mary was under the sentence of death, she took a ring from her finger, which she ordered one of her attendants to deliver to Lord John Hamilton, telling him that it was all she had left to witness her great sense of his family's constant fidelity to her, and desired it should always be kept in the family as a lasting evidence of her regard towards them. This ring is still preserved in the charter-room at Hamilton Palace.

On 5th May, 1625, James, third Marquis and first Duke of Hamilton, was served heir to his father in the lands of Draffan, with the castle of Nethan. He was a firm adherent of Charles I., and in 1649 was beheaded by order of Oliver Cromwell. He was succeeded by his brother William, second Duke of Hamilton, who died of his wounds after the ill-fated affair of Worcester, in 1651. John succeeded Anne Duchess of Hamilton, who married Lord William Douglas, created Earl of Selkirk in 1646, and Duke of Hamilton in 1660. None of those parties repaired or inhabited the Castle of Draffane, probably because the chiefs of the family found a more suitable residence at Hamilton.

In 1660, soon after the restoration of Charles II., we find Andrew Hay designated "of Craignethane." Hamilton of Wishaw, in his account of Lanarkshire, states that "there was in this parish—Lesmahagow—built by Sir James Hamilton of Phenurd, ane great castle, consisting of five towers, called Craignethan, of the ruins whereof Mr. Andrew Hay built a convenient house upon the corner of its garden, after he purchased the same frae the Duchess of Hamilton." The date cut above its northern entrance is 1665. The motive for selling the castle and a portion of the lands of Draffane was that the Hamilton family were deeply sunk in debt.

About 1730 the property was acquired by the Duke of Douglas from Mr. Hay's representatives, and still forms a portion of the extensive possessions of Lord Douglas.

The time being limited, I have deemed it right to bring the historical details to a close, and will now briefly describe, for the benefit of those members of the Society who may not be acquainted with the locality, some of its more salient geological features.

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Railways have done much to further geological investigation. When they are being made, we often get good stratigraphical details in their cuttings and tunnels, and by their help we can take distant runs, at a very moderate expense, and see and understand geological features for ourselves. Geology never opens up her treasure-chest, unless we take to the field, and pick the lock. If we do so, hammer in hand, we can climb the hills, ramble through the glens, descend the mines, or trace the numerous workings of the coal, iron, and limestone spoil heaps, with the rich reward of being able thoroughly to understand, for ourselves, the general deductions of geological truths. In strolling over a locality we observe its valleys, its hills, and its streams, and we are apt to consider that what we see has always existed. When, however, we come to examine more minutely, we find it is not so; the structure of the hills, the undulations of strata, the alterations in the water-courses, and the land configuration, all tell us unmistakeably of many and startling alternations of land and water; of the fierce action of volcanic force; of the more subdued, but no less determined, work of arctic cold. The enquirer, by taking advantage of natural sections, sinking of pits, quarry operations, and railway cuttings, has a very wide range for observation and research amongst the old land and water deposits of former ages, still rich with the vestiges of ancient forms of life, and with the phenomena of physical activity.

Very few districts, indeed, present a more interesting and instructive field to the geologist and palæontologist than does the parish of Lesmahagow. The igneous and stratified rocks shown in its numerous romantic glens give many grand and lofty sections of exceeding interest to the physical geologist, whilst the palæontologist can at various points procure fossil remains in abundance. I may briefly state that we have part of the Silurian, the Old Red Sandstone, and the Carboniferous formations, the latter being well represented, and in numerous localities the various deposits of the Drift series. Igneous rocks occur frequently, causing numerous faults or dislocations, some being of great extent. The economic minerals are abundant, and some are of great value. The Lesmahagow gas or cannel coal is world-famous, whilst the limestones, ironstones, and coals are largely worked. The Silurian and Carboniferous formations have yielded many rare genera and

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species, but the Old Red Sandstone, which extends over a considerable area, has as yet proved almost devoid of organic remains, in this respect resembling the Old Red of the Edinburgh district. In the Tilestones, or Mudstones of the Silurian, there have been discovered, by Dr. Slimon and others, great quantities of most beautifully preserved Crustaceans, such as *Pterygotus bilobus*, *P. ranicips*, *Slimonia acuminata*, and *Ceratiocaris papilio*.

The stratigraphical and palæontological details of Lesmahagow are somewhat similar to those of Carluke parish, as may be seen by the following table:—

SECTION OF STRATA, LESMAHAGOW.

1. Upper Coal Measures.	*Carboniferous or Mountain Limestone.*
2. Millstone Grit.	
3. Upper Limestone.	
4. Middle Coal Measures.	
5. Lower Limestone.	
6. Lower Coal Measures.	
7. Old Red Sandstone.	
8. Silurian Strata.	

Within a very short distance from Craignethan Castle, at the Fence Pit, opened up by the Nitshill and Lesmahagow Coal Co. for the working of the famous Lesmahagow gas coal, we have presented to us a most interesting section, embracing strata of the upper coal measures, down to the base of the middle coal measures, the depth of shaft being 355 yds. 1 ft. 4 in., whilst in the adjoining glens we find the lower limestones, lower coal measures, and Old Red Sandstone.

In the lower limestone series is the oyster band, or *Productus giganteus* bed. It is seen in position in various points through the parish, and contains vast numbers of *Productus giganteus*, some of a very large size, while other molluscous remains are numerous. The main limestone and shales above produce fine cabinet specimens of the various genera and species usually found in the West of Scotland. In ascending the strata we find the position of the Hosie limestone, Raes Gill ironstone beds, 1st calmy limestone, 1st and 2nd Kingshaw limestones, with their accompanying fossiliferous shales, lingula limestone, and lingula beds, all containing vast quantities of fossil remains.

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I now give a section of Fence Pit, as in it we find the various positions of our famous hunting grounds for fossil remains, viz., Lesmahagow gas-coal and ironstone, Maggy ironstones, Howgate limestone, Belstaneburn limestone and shales, Gare limestone and shales, and other higher series. The Levenseat limestone is not represented here, and it seems to be very partial in its distribution, being found only in a few localities, viz., Auchterhead, Cambusnethan, Calderbank, Monkland, Levenseat, and near Bathgate.

SECTION OF CARBONIFEROUS STRATA, FENCE PIT, LESMAHAGOW.

	Faths.	Feet.	Inches.
Surface,	7	1	...
Sandstone, laminated,	...	3	11
Coal (Woodend Coal),	...	2	7
Sandstone,	...	...	11
Shale (Ironstone Balls,)	...	4	9
Fire-clay,	...	...	11
Shale,	1	4	5
Kingle,	...	...	8
Shale,	...	3	5
Coal,	...	...	4
Fire-clay,	...	5	5
Sandstone, laminated,	3	1	11½
Shale,	1	1	4
Sandstone,	...	3	8
Coal,	...	1	0½
Fire-clay,	...	3	1
Shale,	1	4	7½
Sandstone, laminated,	2	1	9
Shale,	...	4	2½
Sandstone, laminated,	...	3	2
Fire-clay,	1	1	11
Sandstone,	2	2	3
Fire-clay,	...	4	1
Sandstone,	1	2	3
Shale,	...	1	9
Coal (Crofthead Coal),	...	2	...
Fire-clay,	...	3	10
Shale,	1	4	...
Coal (Stinking Coal),	...	2	...
Fire-clay,	...	2	8
Sandstone,	...	2	8
Shale,	...	4	3
Sandstone,	...	4	4
Shale,	...	4	3
Coal,	...	2	5
Fire-clay,	...	...	8
Sandstone, laminated,	1	2	...
Shale,	...	1	3
Coal,	...	...	10
Fire-clay,	...	5	9
Shale,	2	...	4
Sandstone,	...	3	...
Shale,	...	1	9
Ironstone (Slatey Ironstone),	...	...	1½
Shale,	...	2	...
Coal,	...	...	9
Fire-clay,	...	1	4
Sandstone, laminated,	...	5	0½
Shale,	...	2	4½
Whinstone,	...	3	3½
Shale,	...	5	11½
Coal,	...	1	7
Fire-clay,	...	1	...
Sandstone, laminated,	...	4	5½
Shale,	...	2	1
Sandstone, laminated,	1	2	10
Shale,	...	3	5
Coal, "Burnt,"	...	...	10
Fire-clay,	...	1	6

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SECTION OF CARBONIFEROUS STRATA—*Continued.*

	Faths.	Feet.	Inches.
Sandstone, laminated,	1	3	9
Ironstone, Limey (Ginstone Ironstone),*	...	...	8½
Sandstone, laminated,	1	1	8
Fire-clay,	...	1	1
Coal,	...	1	3
Fire-clay,	...	...	7
Sandstone, laminated,	...	2	9
Shale,	...	...	3
Coal,	...	...	1
Fire-clay,	...	...	8
Sandstone, laminated,	2	5	9
Shale,	...	5	5½
Sandstone,	...	...	6
Shale,	...	2	9
Sandstone,*	1	1	6
Shale,	2	...	...
Sandstone,	3	...	...
Shale,	...	2	...
Sandstone,	...	...	3
Shale,	...	...	6
Sandstone,	...	...	6
Shale,	1	1	6
Fire-clay,	...	...	6
Ironstone (Curly Ironstone),*	...	...	4
Shale,	...	...	5
Fire-clay,	...	2	...
Sandstone,	1	5	...
Shale,	...	1	2
Sandstone, laminated,	...	5	6
Fire-clay,	1	1	9
Fire-clay, very dark,	...	1	11
Kingle,	...	...	11
Sandstone, laminated,	1	1	8
Fire-clay,	...	2	10
Sandstone, laminated,	1	2	10
Shale,	...	3	1
Coal,	...	...	3
Fire-clay,	1	5	...
Sandstone, laminated,	...	2	10
Coal,	...	...	5
Fire-clay,	...	4	9
Sandstone,	1	4	2
Coal,	...	...	4
Fire-clay,	...	...	10
Coal,	...	...	2
Fire-clay,	...	1	8
Sandstone, laminated,	1	...	...
Fire-clay,	1	1	6
Sandstone,	1	5	10
Coal,	...	...	6
Sandstone, laminated,	...	...	8
Fire-clay,	...	1	7
Sandstone, laminated,	6	5	3
Fire-clay,	...	4	10
Sandstone,	3	...	8
Shale,	...	1	11
Sandstone, laminated,	1	3	...
Shale,*	4	2	...
Sandstone, laminated,	...	2	6
Limestone (Gare Limestone),*	...	3	7
Fire-clay,	...	1	4
Sandstone,	8	5	10
Shale,*	4	3	3
Limestone (Belstaneburn Limestone),*	...	3	2
Shale,*	...	...	3
Sandstone,	...	1	9
Coal,	...	...	3
Sandstone, laminated,	6	3	5
Kingle,	...	1	2
Sandstone, laminated,	2	4	...
Fire-clay,	...	1	10
Coal, "Parrot,"	...	...	4
Sandstone,	1	3	10
Shale,	...	3	...
Fire-clay,	...	3	...
Sandstone,	5	4	2
Shale,*	2	2	...
Limestone (Howgate Limestone),*	...	5	8
Sandstone,	...	...	8

* Fossil remains.

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SECTION OF CARBONIFEROUS STRATA—*Continued.*

	Faths.	Feet.	Inches.
Coal,	...	...	2
Sandstone,	5	4	10
Shale,	...	2	2
Coal,	...	1	2
Sandstone,	1	2	5
Shale,	...	3	6
Coal,	...	...	1
Fire-clay,	...	1	5
Sandstone,	...	3	...
Coal,	...	...	3
Fire-clay and Ironstone Balls,*	...	5	10
Coal,	...	1	4
Fire-clay,	...	2	3
Sandstone,	...	1	7
Shale,	...	1	4
Trap Rock,	1	5	3
Sandstone,	...	...	6
Shale,	...	2	4
Smithy Coal, "Burnt,"	...	1	1
Fire-clay,	...	3	1
Coal,	...	...	3
Sandstone,	...	...	2½
Coal,	...	...	1½
Sandstone, laminated,	1	5	2
Shale,	...	1	4
Sandstone,	...	4	5½
Shale,	...	...	6
Coal,	...	...	4½
Sandstone,	1	...	8
Shale,	...	1	6
Coal,	...	...	6½
Fire-clay,	...	2	...
Sandstone,*	2	2	4
Coal,	...	...	8½
Fire-clay,	...	...	4½
Coal,	...	...	5½
Ironstone,*	...	...	3½
Coal,	...	...	9
Sandstone,	1	...	10½
Shale,*	3	...	9
Ironstone (Maggy Ironstone),*	...	...	3
Shale,*	1	3	...
Sandstone, laminated,	...	2	11
Coal,	...	...	2
Sandstone,*	...	2	3
Fire-clay,	...	2	...
Shale,	...	4	9
Coal,	...	...	10
Shale and Ironstone Balls,*	...	5	3
Gas Coal (Lesmahagow Gas Coal),	...	1	9
Ironstone,*	...	...	4
Fire-clay,	...	...	3
Coal,	...	...	7
Fire-clay,	...	1	...
Coal,	...	...	7
Sandstone, laminated,	4	2	1
Fire-clay,	...	1	...
Sandstone,	...	5	6
Total depth of Shaft,	177	4	4

Before closing these remarks, I cannot refrain from saying a word or two on the Drift series, near the Clyde. I have procured a number of journals (from my friend Mr. Dunlop, Braidwood), showing the depth of sand and gravel at various points, from Foot of Nethan up to Bankend, Crossford, which are as follows:—

	Fathoms.	Feet.
1st. No. 5 Bore, Foot of Nethan, Clydegrove, Sand and Gravel,	9	4

* Fossil remains.

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	Fathoms.	Feet.
2nd. No. 4 Bore, near Clydegrove House,		
Sand and Gravel, ...	8	3
3rd. No. 3 Bore, Clydevale,		
Sand and Gravel. Stopped, ...	4	3
4th. No. 2 Bore, Clydegrove,		
Sand and Gravel, ...	7	4
5th. No. 1 Bore, Clydegrove,		
Sand and Gravel, ...	7	0
6th. No. 1 Bore, Bankend, Crossford,		
Surface Earth and Sand, ...	2	0
Blue Clay with Stones, ...	14	3
7th. No. 2 Bore, Bankend, Crossford,		
Surface Clay and Stones, ...	1	0
Sand and Gravel, ...	4	3
Blue Clay and Stones, ...	2	3

On Laird Lang's property, near Nethan, but up a considerable distance from Clyde, a bore was put down 42 feet through pure sand, and was still in it when boring was left off. Again, on the top of the hill at Crossford, belonging to Mr. Templeton, sand of a fine description is seen cropping out to the surface, and below this about thirty feet of clay is got. On the other side of Clyde, in Carluke parish, in sinking the Gas-coal Pit, at Orchard No. 1, Joseph Reid's garden, the bore passed through eight fathoms of surface clay, and immediately below it came on a bed of pure moss, four feet thick, containing nut shells; below this again was a little blue clay. In working dross coal on the same lands, they came on a part where the coal was worn away by the action of water, the coal being finely polished, and a space where it was wanting being filled up with sand and gravel. From my investigations around the locality, I am led to believe this to have been the ancient water-course of the Mouse water, coming through the Lee valley, where still may be seen great quantities of sand and gravel. The bed of moss under the clay is a curious phenomenon, at all events in this locality, and it seems to me to corroborate the views held by one of our most distinguished geologists, Dr. James Geikie, F.G.S., as to the existence of two glacial epochs, separated by an inter-glacial age, in which the sheet ice disappeared, and the temperature rose to a point admitting of the return of various forms of animal and vegetable life.

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[ABSTRACT.]

XVIII.—ON THE JOINTED PRISMATIC STRUCTURE IN BASALTIC ROCKS. By JAMES THOMSON, LL.D., D.Sc., Professor of Civil Engineering and Mechanics in the University of Glasgow. With three Plates, [II., III., and IV.]

(Read 8th March, 1877.)

THE views presented in the following paper have in great part been previously brought forward and published on some other occasions, but not hitherto in any such way as to become satisfactorily accessible among geologists. The fundamental ideas and primary observations on which they were based were submitted by the author to the Belfast Natural History and Philosophical Society in a paper read on November 26, 1862, and the subject was shortly afterwards brought under the notice of the British Association at the Newcastle Meeting in 1863, and a brief but complete account of the chief points is to be found printed in the Association's Report for that year. A fuller account of the author's views, with his discussion of the prevailing views of others, is printed in the Annual Report of the Belfast Naturalists' Field Club for 1869-70, as an abstract of a paper read by him to that Society in November, 1869. He was afterwards requested to bring the subject before the Geological Society of Glasgow; and the present paper contains a fuller exposition than any previous one, and includes the discussion of a few facts which have later come under notice.

Basaltic Rocks, and rocks generally of the trappean class (which comprises most of those that have originated as volcanic lavas), are very frequently to be found divided into prismatic columns, more or less regular in form, and the columns are sometimes found to be divided into short lengths by cross fractures or surfaces of easy partition, which show a remarkable regularity of form. The columns, however, it is to be particularly noticed, are quite devoid of the kind of exact regularity that belongs to crystals. They vary in the number of their sides from three to

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eight or nine, and it seems that occasionally a column may be found with so many as twelve sides. The angles between the sides have no regularity whatever; those seen in the end or cross-joint or cross-parting of a column, being generally unequal among one another, and the magnitude or obtuseness of any one angle being subject often to considerable variation along the length of the column. Also, in passing along the length of a column, a face may often be found becoming narrower and narrower till at last it dies out, and the adjacent faces may be noticed to twist round, altering their angle of mutual inclination in passing along the column. For such reasons as these, a notion which has often been vaguely entertained, that the columns may be of the nature of gigantic crystals, is to be set aside at once as untenable.

The columns are often remarkably straight and parallel—sometimes they radiate, or, we may rather say, converge, like the spokes of a wheel; and sometimes, though more rarely, they are curved. They are to be met with in various sizes. Sometimes they may be found only an inch across, and sometimes so much as 9 feet; and when small in diameter they may often be short in length—perhaps a few inches or a foot or two long; while columns of larger sizes are often found extending to lengths of 50 or 100 feet, and sometimes even to 200 or 300 feet. In a horizontal layer of basalt, or trap rock, the columns are vertical; in a dyke they are perpendicular to the rock faces which have confined the basalt, trap, or lava in its molten state; and, when occurring in a trough or valley of rock, with irregular configuration of its sides and bottom, some of them may occasionally be found curved along their length. As a general rule the columns are found to abut perpendicularly against the rock faces which have confined their substance in its molten state. The descriptive particulars just given are collected from many observations and sources of information, and seem to be fairly trustworthy so far as they go. But, in the absence of far more trustworthy knowledge of the physical conditions under which the structure has originated than has as yet been attained to, it must be supposed that there may be yet other important features remaining which have hitherto escaped notice, or have been imperfectly described. The well-known and generally-admitted features referred to in the description just given seem to indicate very clearly that the direction of the columns has been somehow imparted to them by the cooling sur-

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faces into contact with which the molten substance has been poured. It seems not unreasonable to suppose that the columns have commenced from the colder surface, proceeding thence into the cooling mass with a tendency to perpendicularity to the colder surface, and that in advancing farther forward longitudinally, they have had a tendency to proceed perpendicularly to successive isothermal interfaces in the cooling mass; or, at least, that their longitudinal configurations, whether straight or curved, and whether parallel or radiating, may have been decided in an important degree by influence of the configurations of the isothermal interfaces existing in the cooling mass during their growth as columns.

Of the opinions which have commonly been entertained among geologists as to the manner in which the jointed prismatic structure has originated, none have appeared to the author satisfactory. They have very generally involved one or other, or a combination of both of the two following principles:—

1st—Prismatic fracture by shrinkage in cooling, like the cracking which may be observed in starch or mud in drying.

2nd—An assumed spheroidal concretionary action of the lava or basalt in solidifying from the molten state.

He gave sketches in fuller detail of the views put forward by several of the leading geologists in various parts of the world, as expressed by those writers themselves, who have either proposed them or have at least promulgated them with favour, though in some cases with vagueness—the natural result, he said, of attempting to explain intrinsically untenable views. Sir Charles Lyell, writing, for instance, in his *Elements of Geology*, under the heading "Columnar and Globular Structure," while appearing to put forward with favour the spheroidal concretionary theory, seems also to be affected with this character of vagueness. Dr. Daubeny, Beete Jukes, and several others, with much more boldness maintain the spheroidal concretionary theory under various modifications of its details. Dr. Daubeny,* for instance, believes that the cause for the columnar arrangement of trap is to be found in the spheroidal or globular structure often shown in these rocks during their disintegration by exposure to the weather. He then says, "It is

* Daubeny, *Volcanos*, 2nd edition, 1848, pp. 660 and 661.

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evident that a series of globular concretions of trap placed in close contact whilst in a pasty condition, or in a state of transition from fusion to solidity, would be by mutual pressure converted into a succession of jointed columns, which, owing to slight differences in the compactness and consequent softness of the several parts of the mass, would rarely be exact in their sizes and in the number of their sides, but would exhibit all those variations which in that respect columnar basalt commonly displays." Dr. Daubeny, in connection with these views, describes a "natural grotto," called the Käse Keller, at Bertrich, near the Mosel, between Coblenz and Trèves (see Plate II., Fig. 1).* It is called the Käse Keller (Cheese Cellar) from the resemblance to Dutch cheeses piled up in columns which is presented by the roughly spheroidal joints of which its columns are made up. He says, "It beautifully illustrates the origin of the jointed columnar structure which this rock so often assumes, since a little more compression would have reduced these globular concretions into a prismatic form, each ball constituting a separate joint in the basaltic mass."†

Dr. Daubeny supposes that in this case the molten lava had been free to flow partly away from among the supposed globular concretions during the time of their solidification and growth, and that thus the supposed globular structure had room freely to develop itself—the surrounding vacancies affording to the balls freedom from much compression, and leaving them free to retain their original globular figure.‡ Dr. Daubeny contrasts the compact prismatic columns at Fingal's Cave at Staffa with the columns, resembling piles of nearly globular cheeses, in this German cave; and accounts for the difference by supposing that the basalt of Staffa was solidified as a continuous bed without there having been freedom for the molten lava to escape from among the supposed balls during their supposed solidification and growth; and he attributes the hollowing out of the Staffa cave in the solid columnar rock to the action of the sea, while the Käse Keller was, he believes, an original cavity in the rock whilst still hot and only partially solidified—a cavity formed by the flowing away of liquid

* This drawing of the Käse Keller is copied from one in Lyell's *Manual of Elementary Geology*, 3rd edition, 1851, p. 386, as that seems to be a better drawing than the sketch at p. 79 in Daubeny's book.

† Daubeny, p. 78. ‡ Daubeny, p. 78.

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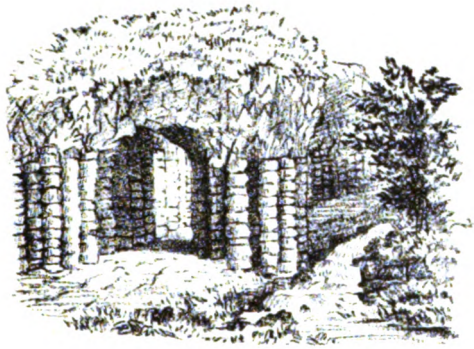

Fig 1 Kase Keller

Fig 2.

Fig 3

Fig 4.

Fig 5

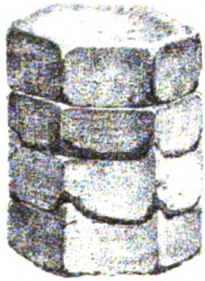

Fig. 6.

Fig 7

Mary H. Thomson del. Smith & Hamilton Lithog.

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basalt from among the supposed piles of globular concretions. In closing his discussion of the subject, Dr. Daubeny distinctly announces, as the conclusion he arrives at, "that the spheroidal structure will be found to be one of the most prevalent in rocks of the trap family, and that the prismatic structure is in general only a consequence of the spheroidal." *

The views put forward in detail by Dr. Daubeny have here been briefly cited, as they constitute a fair enough specimen of the general character of views offered, though with many variations, by different geologists of note. Mr. Scrope, however, repudiates the spheroidal concretionary theory, denying that the columnar structure could have had its origin in spheroids pressing against each other, pointing out, that imbedded knots of olivine are often to be found severed apart by the seam which separates two contiguous columns; and he thence argues, "that it is impossible to talk any longer of the columnar structure being occasioned by the mutual pressure of spherical concretions."† He then himself maintains that the columns have originated through "fissuring" of the hot rock by "contraction" during its process of "consolidation" or "refrigeration," and he supposes the cross-joints to have been formed contemporaneously at each part of the length of the column with the advance of the prismatic fissures ‡ at that same place, the cross-joints being supposed to be successive bounding faces between the solidified end of the column and the as yet molten lava into which the solidification is advancing, and the prismatic fissures being supposed

* Daubeny, p. 661.

† See citation from Scrope in Daubeny's second edition, page 65, note. (A passage nearly to the same effect as this citation is to be found in Scrope, *Volcanos*, revised and enlarged second edition of date 1872, pages 103 and 104, foot-note.) Daubeny, in his passage just referred to, follows up his citation from Scrope about the knots of olivine by dissenting from Scrope's conclusion, and still maintaining that the columns have been formed by spherical concretions which, while forming themselves by mutual pressure into columns, would be still in a soft and pasty state; but asserting that the seams or severances between the columns, and cutting through the knots of olivine, might take place by shrinkage after consolidation. The general tenor of the arguments in the controversy between Daubeny and Scrope exhibits strikingly an utter bewilderment pervading the minds of both on this subject.

‡ Scrope, *Volcanos*, 2nd ed., 1862, page 104.

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at each period to extend quite forward to the molten lava.* Mr. Scrope's view, as he himself states in the passage referred to, comprises the supposition that the concavity of the ball-and-socket-like cross-joints ought to be always directed upwards—that is, nearly in his own words, in the direction facing away from the surface of refrigeration, which he believes to be uniformly the bottom or base of the lava bed; or, in other words, that each separate piece of the jointed column ought, according to his supposition, to have its bottom convex and its top concave. This supposition, the author (Professor Thomson) remarks, is not verified, but is decidedly controverted by the basaltic columns of the Giant's Causeway, the cross-joints being often concave upwards, and often concave downwards, and often nearly flat: and this one circumstance, even by itself alone, Prof. Thomson considers must set aside the suppositions maintained by Mr. Scrope. That the cross-joints as exposed to view in the Giant's Causeway are some of them convex upwards, and some concave upwards, is very clearly shown in Plate III., Figs. 8 and 9, which are accurately copied from excellent photographs selected by the author on a visit to the Causeway when he was scrutinizing the stones themselves, and found the photographs to give good representations of various features important for the geological considerations under discussion in the present paper. It may be noticed, that in each of these two drawings some of the exposed joints forming the tops of the columns left remaining are convex upwards, and that others are concave upwards; and that some of the concave ones in Fig. 9 are distinctly indicated by their having rain water lying in their hollow tops.

Professor Thomson then gave a discussion of the spheroidal concretionary theory. He showed many objections to it, any one of which separately, he said, might be sufficient to set it aside. He believes it to be founded from the outset on a total mistake. He regards the spheroids so often met with in decaying basalts or lavas as being not concretions at all, but as being the results of decay or decomposition penetrating from without inwards in blocks, into which the rock has been divided by fissures, which may have arisen from various causes. Examples of such spheroidal

* Scrope, *Volcanos*, 2nd ed., 1862, p. 104. Much, if not all, of the same remains in Scrope, revised and enlarged second edition, 1872.

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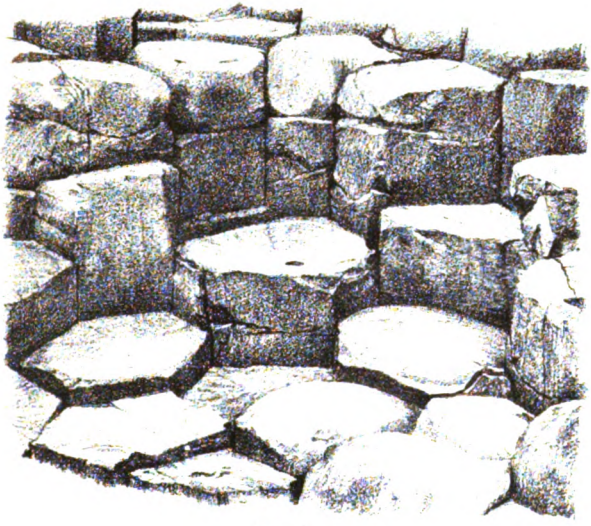

Fig. 8.

Fig. 9.

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exfoliations are shown in Plate II., Figs. 2 and 3. Fig. 2 is a drawing from an actual stone picked up on a hillside, and which may be assumed to have been long exposed to weathering. The stone itself when scrutinized shows at least six distinct shells or coats surrounding a nucleus. Fig. 4 is given as a drawing from Prof. Thomson's own observations of exfoliation proceeding inwards in blocks of shattered trap noticed *in situ* in a quarry near Largs, or of exfoliation such as may often be seen elsewhere in shattered basaltic or trap rocks *in situ;* and as indicating clearly that the positions of the several foliations and nuclei are determined, not by any original concretionary action, but by the casual cracks produced, it may be supposed, by earthquakes at various times. In reference further to the concretionary theories of basaltic columns, he pointed out that even if concretions were forming in a cooling mass of molten basalt or lava, we have no right to suppose that they would arrange themselves in straight, or nearly straight, rows, like beads on a vast number of parallel strings; nor that, if they did exist, and were so arranged, those in any two adjoining rows would so meet as, in pressing against each other, to form continuous columnar faces; and he gave various other reasons, though those here cited may amply suffice. He believes that no credence whatever ought to be given to any form or modification of the spheroidal concretionary theory of the jointed prismatic structure, but that it ought to be utterly and promptly rejected from the science of Geology, without any vestige of it being retained to confuse the investigation of the subject in the future.

Professor Thomson proceeded to give his own theory, which may be briefly sketched out as follows:—He supposes that the division into prisms has arisen by splitting, through shrinkage, of a very homogeneous mass in cooling, and thus far his explanation is in agreement with parts of the views of some of those who have previously speculated on the subject. Beyond the mere attribution of the mode of origin of the prismatic columnar structure to splitting through shrinkage in cooling, like the cracking which may be observed in starch or mud in drying, he offers some explanations as to what conditions, affecting the stresses in the interior of the mass, and involving the influences of contemporaneity or of sequence in time of different parts of the fissure system, must accompany the progress of the system through

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the interior of the mass. He shows how the splitting action in the interior is distinct in essential features from any such cracking as is exhibited *on the surface* of mud in drying, and from the cracking into a tesselated pattern, of the glaze on porcelain, or of the varnish on terrestrial or celestial globes. On this subject, briefly mentioned at this stage, his remarks will be cited more fully further on in the present abstract. He thinks there yet remains ample scope for much additional scrutiny, both observational and theoretical, towards fuller elucidation of the conditions accompanying the remarkable results presented by the prismatic structure often met with in basaltic and various other rocks, and other substances.

The "cross-joints," he specially remarks, are in no way essential to the formation of the prismatic structure; for the columns are not always jointed, but are sometimes found quite continuous for lengths great relatively to their diameters, so as to constitute long bars of stone. In excavations, for instance, which were made for the formation of the new Cemetery at Belfast, columnar structure in basalt or other trap rock was met with, the columns being often many feet in length, and only a few inches in diameter. Plate II., Fig. 5, shows a portion of one of those long columnar bars which were devoid of the so-called cross-joints.

The chief new view, which had originated with himself in connection with this subject, and which he offers as a contribution towards the development of any true theory, depends on a supposition which had occurred to him in August, 1861, through careful scrutiny and consideration of appearances presented by stones in the Giant's Causeway. This supposition is that the so-called "cross-joints" are fractures which have commenced in the centre of the column, and have advanced to the outside as a circle increasing in diameter. This mode of fracture, he thinks, is evidenced by various markings which he has specially observed in many stones of the Giant's Causeway. These stones usually show a remarkably symmetrical conformation round the outer parts of their cross-joint faces, a conformation which has commonly been associated in idea with ball-and-socket jointing, and has often been attributed to spheroidal concretionary growth; but which to him had presented appearances (see Plates II., III., and IV., Figs. 6, 8, 9, 10, and 11) suggestive of a connection, in nature and mode of origin, with those appearances which are remarkable in an ordinary

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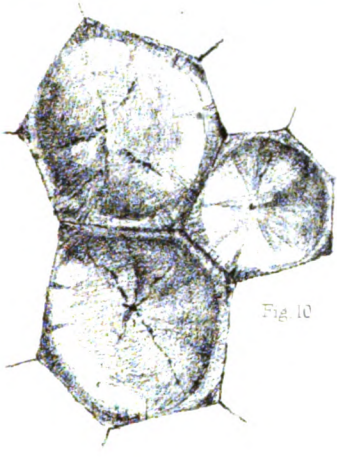

Fig. 10

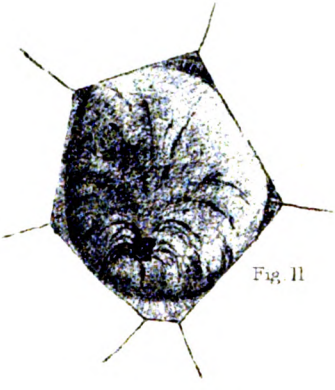

Fig. 11

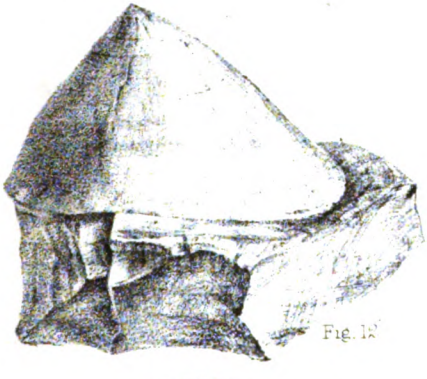

Fig. 12

Fig 13

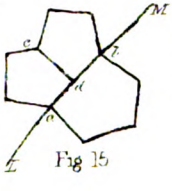

Fig 15

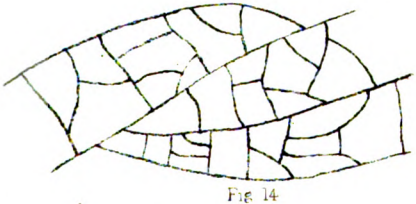

Fig. 14

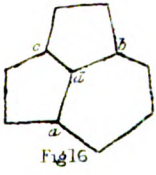

Fig 16

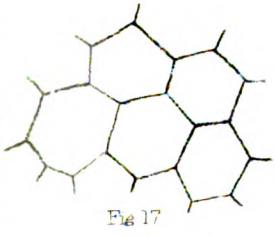

Fig 17

Fig 18

Mary H. Thomson del. Smith & Hamilton lithog.

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conchoidal fracture—subject to the important distinction, however, that while the conchoidal fracture, in ordinary cases, has emanated from an external spot of the stone where the blow has been struck, the supposed conchoidal fracture across the column appears to have started into existence at the centre, or at some internal spot in the column, and to have flashed thence with a complete circular advancing front towards the exterior of the column. The kind of fracture thus imagined may be briefly designated as a *circular conchoidal fracture.*

On the cross-joint faces, or surfaces of transverse partition, in numerous instances he has noticed roughly figured rays spreading out from or converging towards the centre or some other internal spot in the face. These appeared to him, from the time of his first observing them, in or before 1863,* to be of the same nature as the well known fan-like radial markings of a conchoidal fracture.

Following up the train of consideration and scrutiny thus suggested, he remarks that there are not many very distinct ways in which we can suppose a fissure to have spread across a column or prism of solid stone. First, if we for a moment suppose the fissure to have begun at one side of the column, and to have advanced across to the opposite side, we must expect to find the resulting fracture quite unsymmetrical, and presenting very different appearances at the places where it entered the previously unbroken stone prism, and where it came to its termination, leaving the column broken behind its advancing front. No such appearance is to be found in any of the ordinarily shaped cross-joints; but, on the contrary, there is commonly a very remarkable appearance of approximate symmetry of character in the cross-joint with respect to the different sides and angles of the column. Perfect symmetry is, of course, not to be expected, as the columns themselves are often far from being of any regular or symmetrical form; but, so far as Professor Thomson's observations of the stones in the Giant's Causeway have extended, he believes no appearance is to be found indicating an advance of the fissure across the column from one side to the opposite, in any of the joints which exhibit, in other respects, the usual remarkable features. There may, no doubt, be numerous cases of fracture due to shattering,

* Mention of these rays as noticed by the author is to be found published in an abstract of a paper by him, in the *British Association Report*, Newcastle Meeting, 1863, p. 89 of part 2 of the *Report.*

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by causes different from those which have produced the ordinary remarkable transverse severances. Next, any idea that the cracking of the column could have simultaneously begun all round the circumference, and advanced to terminate in the centre, requires little more than to be brought before the mind for consideration to be rejected as untenable. There seems, then, to remain nothing to suppose but that the ordinary cross-joint fissures first came into existence in the interior of the column, and then flashed out thence towards the circumference.

In order to produce the cross fractures commencing in the centre, he supposes that a longitudinal tensile stress must have existed in the middle of each column previously to the cracking of the cross-joints. To account for such a tensile stress, he suggests, as a probable hypothesis, that after the column was formed, chemical action, caused by infiltration of water, might cause an expansion of the outside of the column, and that the outer part, thus growing longer, would pull the internal part more and more intensely, until at last the internal part would give way, and break into short lengths. The fissures thus formed, it is obvious, must stop short without extending quite to the outside of the column, as the pull causing the fracture in the interior is due purely to longitudinal push in the outer part of the column. That outer part, therefore, will not be subjected to the pull at all, and so the enlarging circular conchoidal fracture should be expected to stop short without penetrating to the outside of the column, especially at the angles. On the event of the central part cracking, and so ceasing to bear a pull, the outer part, being less resisted than before, would increase in length in the immediate neighbourhood of the new internal fissure, and so would bring parts nearer the circumference than before into the condition of being subject to a pulling stress. Also, the reverberation or tremor at the instant of the cracking might, it seems reasonable to suppose, carry the advancing circular edge of the fissure somewhat further out than the region which would be subjected to a pull if the action were slow instead of being by a start. The appearances of the cross-joints—with the central area of each like a circular or oval flattish face, or like the convex or concave form of a watch-glass, but not extending out quite to the angles, and usually not quite out to the sides of the columns—seem to be in accordance with the suppositions here made, and to give considerable corrobora-

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tion to them (see Plates II., III., and IV., Figs. 6, 8, 9, 10, and 11).

The cracks, if formed as supposed, without extending quite to the outside of the column, would constitute places of weakness, from which, under the shattering influence of earthquakes or other causes, fresh fractures would readily proceed quite to the outside, severing the columns completely across; but these fresh fractures occurring in ways quite different from those in which the original circular ones had done, could not be expected to be in continuity with the supposed original circularly terminating fissures. Thus is accounted for the approximately circular outer boundary to the flattish or lunette-shaped middle part of the cross-joint, which is very commonly to be seen.

On a visit to the Giant's Causeway in the summer of 1869, Professor Thomson had noticed some phenomena tending to confirm his previously formed views. He met with several instances in which a small mass of stone, different in texture and in hardness from the rest of the basalt, showed itself in the cross-joint of the column, and in which the joint presented to his view the appearance as if the cross fracture had originated at, and spread out from, this spot of irregular quality. When this extraneous or irregular lump happened to be near the middle of a column, there appeared to emanate from it in all directions approximately straight but roughly formed rays (see Fig. 10, Plate IV., and Fig. 8, Plate III., with the explanation in foot-note);* and when the lump happened to be near one side of the column, the rays emanating from it spread out in curved forms like a brush, and the several rays in proceeding outwards seemed

* Fig 10, Plate IV., shows the general character of features frequently to be noticed with approximately straight rays emanating from about the centre of the column. In this figure, in one or more of the columns, a nucleus or lump of a different kind of stone is shown in the centre, in imitation of what has been noticed by the author in several cases in which a distinctly observable nucleus appeared to him to have originated the fracture. Fig. 8, Plate III., is accurately drawn from a photograph of the group of stones ordinarily shown by the Causeway guides to visitors as the "Ladies' Wishing Chair." Of the columns here shown the one at the left front of a person sitting in the chair shows faintly in the figure, but shows, or at least when last seen by the author, did show very distinctly the appearance, on its top, of radiating striæ or roughly formed rays, which seemed to betoken a conchoidal fracture.

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to bend gently somewhat towards the nearest external face of the column (see Fig. 11, Plate IV., and its explanation in footnote).* This seemed as if they had tended to run so as at each moment to be advancing in a direction approximately perpendicular to the advancing circular or oval edge of the enlarging fissure. If a fracture originating at one side of a column were to advance across to the other side, and in so doing were to cut across any irregular lump in the mass, that lump would leave a kind of tail extending from itself forward in the direction of propagation of the fissure; but the part of the fissure formed before arrival of the fissure's edge at the lump would be scarcely at all influenced by the presence of that irregularity. A tail emanating in this way from an irregular lump or a vesicular cavity, and extending forward in the direction of advance of the crack, is continually to be noticed in the breakage of flints, glass, basalts, and other brittle substances. Now, the cases noticed at the Giant's Causeway, in which, from an included lump, the lines radiated out in various directions, and were curved when the lump was eccentric, tend to corroborate the supposition that the fissure had its beginning at the irregular lump, where some local weakness or overstraining might exist, and that it flashed out from thence towards the circumference of the column.

He mentioned that, in favour of his supposition of possibility of a crack commencing at some central point, and diverging outwards with an enlarging circle as its front or edge, so as to constitute a circular conchoidal fracture, a remarkable confirmation had, long after the publication of his views as to the nature of the cross-partings in basaltic columnar structure, presented itself to him in the features of a broken flint found casually in a heap of broken stones. This flint, which he showed at the meeting, is represented in Fig. 12, Plate IV. The appearances presented by this piece of flint, in its cone with divergent rays, lead to the belief that it must

* Fig. 11, Plate IV., is copied accurately in outlines and all essential features from a drawing of an actual column in the Giant's Causeway. The original drawing was made by the author (Professor Thomson), not from memory, but while standing over the stone, and imitating carefully all the main features. The nucleus from which the brush emanates was of a very hard, dark-coloured stone. The original of this drawing he has carefully preserved for security against casual development of modified features in the making of copies.

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have received the remarkable conical part of its configuration through a blow struck, on an originally larger mass of flint, at the spot where there is now the vertex of the cone; and that, from the point of impact, a fissure must have flashed out in conical form, with a divergent or expanding circle as its advancing front or edge. That any uncrushed material should remain at the place of violent impact to form the smooth point of the cone, might be thought scarcely credible; but confirmation as to this supposition is to be obtained through noticing divergent cracks, which may occasionally be seen in solid glass balls used as children's playthings, like boys' marbles. These balls, after having been knocked about, sometimes show cracks, with circular margins, penetrating into the interior from points of impact, and which may be characterized, along with such as the one just referred to in the flint, by calling them *conical conchoidal fractures.* These fractures have resemblance in shape to limpet shells. An example of these in the glass balls he showed at the meeting, as also another broken flint, which he had subsequently found, showing a like conical feature to that of the one first noticed, and indicating that the first one is not to be regarded as an isolated result of casual circumstances unlikely to recur; but that there must exist some tendency, or readiness, to the formation of such fractures emanating from spots of violent straining in some cases of impact.

He adduced another confirmation of his view as to the cross-partings in the columns—a confirmation which had been found and carefully considered by Mr. W. Chandler Roberts. It was in a piece of indurated clay or red ochre that the confirmatory phenomena were met with. Mr. Roberts, when on a geological excursion to the Giant's Causeway, at the close of the Belfast Meeting of the British Association in 1874, just after attention had been freshly brought to bear on the subject by papers read by himself and the author at that meeting, happened to find the piece of red ochre, and was struck with its features as being remarkable in their resemblance to those specially noticed under the views of Professor Thomson in regard to the cross-partings in basaltic columns. Mr. Roberts carefully preserved the specimen, and, by his kindness, Professor Thomson was enabled to show it at the meeting of the Glasgow Geological Society; and it is well represented in Fig. 13, Plate IV., where it is shown on a slightly

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enlarged scale, the lineal dimensions being increased to about 1½ of the corresponding lengths in the little block of ochre itself, which is of a roughly cubical form, and about the size of a hazel nut. One face of this little block shows very remarkably the same kind of features as those which, met with in basaltic columns, are specially brought into notice in Figs. 10 and 11, Plate IV. There is a speck or granule from which, as it appears, a divergent circular conchoidal fracture has originated; there is a lunette-shaped portion bounded by a circular or somewhat oval margin, where some delay or vibration in the propagation of the advancing fissure may be supposed probably to have occurred, and to have left its mark. Outside of this margin, very distinctly marked, radiating, brush-like striæ are situated, and these seem to show that, after some delay or modification which left the oval margin marked, the fissure had continued to advance outwards. This wonderful miniature occurrence, seemingly of the same kind of fracturing process as appears to have occurred in a large way and with multitudinous repetition in the rock of the Giant's Causeway itself, is not to be supposed to have any special connection, in virtue of locality, with the basaltic structure there. The little block of ochre, though found near the Causeway, is not to be supposed to be part of a tiny column, such as those of the Causeway, and due to the same set of localized causes. Its occurrence there, and its discovery there, must be attributed merely to casual coincidences.

In respect to the manner in which the fissuring of the rock longitudinally into columns may be supposed to have occurred, the author drew special attention to distinctions in the circumstances, on the one hand, under which a tesselated system of cracking can spread out over an extensive surface of mud in drying, as in cases when the water is drawn off from a pond having a smooth, muddy bottom, or under which tesselating cracks often spread over the surface of the glaze of porcelain, or over the varnish of terrestrial or celestial globes; and on the other hand, under which a fissure system can penetrate with columnar configuration through the interior of a mass of rock. In the spreading of a system of tesselating cracks over a surface of shrinking mud, or over the glaze of porcelain—which, probably by penetration of moisture, or from some other cause, may be supposed to swell more than the film of glaze on its surface can endure—or over the varnish of a globe, it is usually to be noticed

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that a few long and often approximately straight or moderately curved fissures first break out, and that other fissures break transversely to them, but generally or always stop on abutting against any previously formed fissure; and that the subdivision or tesselation may, by successive transverse cracks, each stopping against a previous one, be carried on more and more. This is exemplified in Fig. 14, Plate IV., where the order of sequence of the successive breakages in many cases can readily be judged of by noticing that, when one crack abuts against another, which extends continuously across the point of abutment, the abutting one is the posterior of the two. This kind of tesselation is, however, very essentially distinct from that which is to be seen in walking over the Giant's Causeway, or in examining the configuration of basaltic rocks in general. In the tesselation occurring in basaltic rocks (see Fig. 17, Plate IV.) we never find any of the regularly formed fissures of the column side faces abutting against any flat column face. No such configuration is met with as is sketched in Fig. 18. Wherever a separating fissure between two columns meets another column, at that place there is an edge or arris line of meeting of two faces of that other column—that is to say, that regularly or ordinarily three fissures separating three columns radiate out from one common arris line for all the three (see Fig. 17, also Fig. 16). It seems that even if, from any cause —as, for instance, in the case of a mud surface in drying—there were formed a long, straight, or curved crack, such as L M, Fig. 15, and if another crack, *c d*, were to terminate against it, as at *d*, the part *a b* being straight or curved, a change would take place during the inward advance of the fissuring into the body of the mass, under which *a d* and *d b* would cease to be continuous, and would come to form an angle, *a d b*, somewhat as shown in Fig. 16.

He called attention to a class of facts which within recent years had been brought prominently into notice in connection with opinions which may or can be held regarding the mode, or possibly varied modes of formation of columnar structure in rocks. Mr. W. Chandler Roberts, at the Belfast Meeting of the British Association in 1874, had pointed out that a prismatic structure, closely resembling that of basalts, can be produced artificially at will in certain brick-like masses of fire-clay and sand, by heating them under certain conditions to redness—a temperature far below that at which they would fuse. This indicated still more strikingly

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than had previously been done by the columnar cracking of starch, and some other substances not molten, that a process of cooling from the molten state is not at all essential to the formation of columnar structure resembling that of basalts. In the case of basalts, undoubtedly, cooling from the molten state has occurred, and we may suppose that the columnar fissuring took place at some stage in the process of cooling.

He also referred to the existence of columnar structure in sandstones, which had recently been brought into notice among geologists in a paper by Mr. David Corse Glen, F.G.S., printed in the Society's *Transactions*, Vol. V., p. 154, 1873, relating chiefly to columnar sandstone at Kilchattan, in the island of Bute. In the development and discussion of theories as to the columnar structure in basalts, previously to this paper by Mr. Glen, the existence of columnar structure in sandstones had, so far as Professor Thomson knew, been quite unnoticed; and, if at all mentioned, he believed had not been introduced in any important way into consideration. The notion of the columnar structure having instituted itself by some concretionary or other action within the material undergoing solidification, but barely solidified from the molten state, had indeed commonly exercised a too dominant influence in the consideration of the subject. It is important to notice that the sandstone columns of Kilchattan, in Bute, are quite devoid of any such cross-jointing, or cross-parting, as that which is remarkable in the columns of the Giant's Causeway. The longitudinal direction of the columns is nearly vertical, and they cross the planes of stratification obliquely at an angle of about 60°. Their direction and configuration seem to have been determined quite independently of the stratification. Fig. 7, Plate II., is a drawing of a portion taken from one of these sandstone columns of Bute. The strata show themselves passing obliquely across the column, being distinctly indicated through varieties of colouring and grain; and they are represented in the drawing. This column is about 5 inches in diameter; and the set of columns are stated by Mr. Glen as varying in size from 6 or 7 inches diameter down to half an inch The manner in which these columns have originated, and the circumstances which have determined their sizes, or some average sizes which they might tend to assume rather than other very different sizes, must remain as important, and probably as very difficult, matters for research and for theoretical speculation.

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PROCEEDINGS FOR THE SESSION 1876-77.

12th OCTOBER, 1876.

Mr. JOHN YOUNG, F.G.S., *Vice-President*, in the Chair.

Mr. HUGH M'PHAIL exhibited specimens of Fluorite, which he had recently obtained from a vein of Calcite filling a fissure in limestone, near Tralee, County Kerry. The Fluorite of this locality has a deep purple colour, and forms detached crystals of irregular form embedded in the white Calcite, the two minerals thus contrasting strongly with each other. Fluorite is only known to occur in the West of Scotland at one place, viz., at Kempock Point, near Gourock, where it is found in drusy cavities of the trap rock.

The CHAIRMAN and Mr. JOHN MAYER, F.G.S., also made some remarks, the latter speaking of the chemical composition of Fluorite.

The CHAIRMAN exhibited specimens of Siderite, or Carbonate of Iron, which, along with encrusting reniform masses of a variety of Calcite, were found partially filling the cavities in a brecciated iron ore from Cumberland. The Calcite resembled Calamine or Smithsonite so closely in its mode of occurrence as readily to be mistaken for these ores of zinc. It can, however, readily be detected by the blow-pipe test, and by its more rapid effervescence in acids. In the specimens exhibited, the Siderite crystals appeared to be coated by a thin film of some metallic oxide, which gave them a beautiful golden sheen of a rich yellowish-green colour.

Mr. D. C. GLEN, F.G.S., also made some remarks on these specimens, which were presented to the Hunterian Museum by Mr. John Smith, Eglinton Iron-works, Kilwinning.

Mr. ROBERT CRAIG, Langside, Beith, *Corresponding Member*, read a paper on "The Fossils of the Upper Series of the Lower Carboniferous Limestones in the Beith and Dalry Districts of North Ayrshire." (See page 1.) Owing to the lateness of the hour, any discussion was postponed until next Meeting.

Mr. MURDOCH read a paragraph, which had appeared in the *Herald*, describing a find of bones which had taken place on the north bank of the Clyde, in excavating for the foundation of the New Railway Bridge at the Broomielaw, and which were said to be lying *at a depth of 60 feet below the water-level.* On making inquiries he found, from the contractor, Mr. Arrol, that the bones were found only a few feet under the level of the old roadway along the river bank, and not so far down as the water-level. This showed that great caution should be exercised in accepting the statements made by newspaper correspondents on the authority of workmen and others.

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2nd November, 1876.

Annual General Business Meeting.

Mr. D. C. Glen, F.G.S., in the Chair.

Messrs. John Aitken, John M'Lauchlan, George K. Walton, E. M. Dixon, J. W. M'Nellan, J. D. Brown, Archd. Millar, James Allan, James Hunter, G. S. Wilks, David Stewart, James Henderson, and Forrest M'Nee, were elected Ordinary Members of the Society.

Mr. Murdoch, *Secretary*, read the Annual Report of the Council for the past Session, as follows:—

At the commencement of the Nineteenth Session of the Society, the Council beg to submit to the Members the Annual General Report for the past year.

The Membership continues to be maintained at about the average of late years. The names on the roll number 198, of whom 181 have paid their subscriptions, leaving 17 in arrears. During the year 23 new Members have joined the Society. Satisfactory as this state of matters is, the Council believe that a considerable increase might easily be made to the list, if Members would make a little exertion to secure their friends as Members. Although, as will be seen by the Treasurer's Report, the funds are in a better state than they were, yet any addition to the revenue would still be useful.

The Ordinary Meetings have been well attended during the Session. A number of papers of interest and value have been read, and many varied specimens have been exhibited. Copious reports of the proceedings have appeared shortly after each Meeting in the columns of the *North British Daily Mail*, and to the Editor of that newspaper the thanks of the Society are consequently due.

The Council may remind the Society of what has often before been stated, it is extremely desirable that more of the Members should come forward to take part in the work of the Meetings. Long or exhaustive papers will of course be welcome, but not more so than short notes and observations.

The Occasional or Special Meetings only comprised two during the Session. At the first, Mr. Wünsch, one of your Vice-Presidents, delivered the Annual Address, in lieu of, and at the request of Sir William Thomson, your President, whose time would not allow him to undertake the duty. At the second Meeting Prof. Geikie gave an interesting paper upon the Old Red Sandstone, which the Council hopes to have the privilege of publishing in the forthcoming part of the *Transactions*. (For a full abstract, see Vol. V., Part ii., 1877, page 276).

The Excursions of the Year were to the following localities:—

	Conducted by
April 1—Beith,	Mr. Robert Craig.
,, 29—High Blantyre,	Mr. D. C. Glen, F.G.S.
May 13—Uddingstone,	Mr. Daniel Wilson.
,, 25 (Queen's Birthday).—Touch Hills and Stirling,	Mr. John Young, F.G.S.
June 3—Milngavie and Strathblane,	Mr. James Dairon.

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A considerable number of the Members took advantage of these opportunities for visiting the interesting localities named, and to the gentlemen who acted as conductors, the thanks of the Society are due.

THE LIBRARY continues to be used by the Members to some extent. Numerous additions have been made in the shape of exchanges and donations from other Societies with whom there is correspondence. So soon as the state of the funds will permit of the needful expenditure for additional book-case accommodation and for binding, these additions will be arranged and added to the Catalogue. Exchanges are made with many of the leading Scientific Societies both at home and abroad, and there is constant evidence of the estimation in which the *Transactions* are held from the increasing applications for them by Societies not previously on the exchange list.

THE MUSEUM remains without change, except that the location of some of the cases is shifted, owing to the change of the Society's room, which, as Members are aware, has been caused by the temporary requirements of the Trustees of Anderson's University. As additional rooms are about to be built, the council expect that by another year the Society will have the choice of better accommodation than it has hitherto had.

THE TRANSACTIONS have not received any additions during the past year, owing to the want of funds. The Council believe that now, however, they are warranted in printing another part, and as material for it is well in hand, no long time ought to elapse before its issue.

The long-talked-of reissue of Prof. Geikie's paper on the Glacial Drift has now been made, and as the Council do not wish its cost to be any burden on the funds, Members are requested to take up as many copies as possible. Sets of *Transactions* up to the end of Vol. IV. are to be had by Members, by a resolution of the Council, for a short time, at the reduced rate of £1, and it is hoped that this liberal offer will be taken advantage of.

THE BRITISH ASSOCIATION MEETING OF 1876.—In conclusion, the Council would congratulate the Society upon the great success of the Glasgow Meeting of the British Association held last September, and in the proceedings of which Geology took such a prominent place. More than one of the Members of this Society contributed papers to section C; the local Geological Guide, "A Catalogue of the Western Scottish Fossils," was entirely the work of several of the Society's Members—Dr. Young, and Messrs. Armstrong, Glen, D. Robertson, and John Young; and the exhibitions held in the Hunterian Museum and at the Corporation Galleries were largely the outcome of the labours of various Members.

The TREASURER, Mr. Wight, read his Annual Financial Statement, an abstract of which will be found at page 154.

The adoption of both Reports was moved by the Chairman, and unanimously agreed to.

Mr. Wünsch's resignation of the Vice-Presidentship having been announced by the Secretary, Mr. Kirsop moved that a cordial vote of thanks be given to Mr. Wünsch, for the work he had done for the Society, now extending over a number of years, which was seconded by Mr. Barr,

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and cordially agreed to. The Secretary was instructed to send Mr. Wünsch an extract of the Minute embodying this resolution.

The following gentlemen were elected to fill the vacancies amongst the office-bearers of the Society:—Mr. James Dairon as Vice-President; Messrs. James Armstrong, D. C. Glen, F.G.S., John Kirsop, and William Baxter, as Members of Council. Mr. J. B. Murdoch and Mr. John Burns were re-elected Secretaries; Mr. John Wight, Treasurer, and Mr. Richard Neilson, Librarian. Messrs. Mason and Schuman were elected Auditors of Accounts for the ensuing year.

During the evening the Chairman made some remarks upon the recent Meeting of the British Association in Glasgow, adverting more especially to the Geological exhibition by Members of the Society at the Corporation Galleries and at the Hunterian Museum.

Mr. JOHN YOUNG, F.G.S., in speaking of the same subject, stated, that Prof. Roemer of Breslau said he had never seen Geological specimens mounted and displayed to such advantage as those of the Glasgow Geologists, a statement of which the Society might well be proud. Mr. Young said the thanks of the Members were especially due to Mr. Glen for the work he had done in connection with the British Association Meeting.

7th DECEMBER, 1876.

Mr. JAMES DAIRON, *Vice-President*, in the Chair.

Messrs. Walter Burns and Hugh Stewart were elected ordinary members.

Mr. ROBERT CRAIG, Langside, Beith, exhibited a small boulder of Carboniferous coralline limestone dredged a number of years ago from Ayr Harbour, and kindly lent for exhibition by Mr. M'Cririck, Gunsmith, Ayr. It bore marks of scratching and polishing, and contained corals found in Ayrshire strata.

Mr. JAMES THOMSON, F.G.S., remarked that this boulder was of great interest. He identified some of the contained corals as belonging to the new genus *Koninckiophyllum*, established by Prof. Nicholson and himself for the reception of a group of corals characterizing the upper division of the lower limestone, and which had not as yet been discovered in any other horizon. There were two localities to which this boulder might be referred —one about two miles above Sorn on the river Ayr; the other at the side of a burn between Upper Fenwick and Dunlop, the latter being the most probable spot.

Mr. A. PRATT exhibited a series of Heads and Stems of Crinoids which he had got near Inverteil, Fifeshire, accompanied by a number of beautiful drawings of species, both as fossils and restored as they probably lived in the waters of their native seas. (For Mr. Pratt's remarks, see page 25.)

The discussion on Mr. Craig's paper on the Fossils of the Upper Series of the Lower Ayrshire Limestones, postponed from the Meeting of 12th October, was taken up—the author giving a short *resumé* of the main

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points of his paper. Mr. J. THOMSON, F.G.S., though differing to some extent from Mr. Craig's conclusions, congratulated the Society in having had placed before it a paper of such interest and value.

Mr. JOHN YOUNG, F.G.S., read Remarks upon Prof. Hull's proposed triple division of the Carboniferous Strata, as contained in his paper read before Section C of the British Association Meeting, held in Glasgow last September. (For an abstract, see page 26.)

Mr. JAMES NEILSON, jun., and Mr. JAMES THOMSON, F.G.S., agreed generally with Mr. Young's estimate of Prof. Hull's proposition, and thought, that however such a classification might be adapted for the English or Irish Carboniferous systems, it was not suited for the Scottish strata.

Mr. DUGALD BELL, late Secretary of the Society, expressed his gratification at being again present at a Meeting, and at seeing so many of the well-known faces, and at hearing evidence that the cause they had all at heart was progressing favourably. Mr. Bell said that his work in the Society had been of use to him in India; and he gave a few interesting particulars regarding the districts which he had visited there.

19th JANUARY, 1877.

Mr. JOHN YOUNG, F.G.S., *Vice-President*, in the Chair.

Mr. John Dansken was elected a Life Member, and Mr. James Dobie an Ordinary Member.

Mr. DAVID ROBERTSON, F.L.S., F.G.S., read a paper, entitled "Notes on the Post-tertiary Deposits of Misk Pit, Kilwinning." (See Vol. V., Part II., page 297.)

In illustration of his paper, Mr. Robertson exhibited a fine series of specimens from Misk Pit, and also from the neighbouring deposit on the bank of Garnock Water.

Mr. JAMES NEILSON, jun., congratulated the Society upon the reception of this paper. He believed that the whole series of Mr. Robertson's Post-tertiary papers would form, when completed, as noble a contribution as had ever been given by any member to any society.

Mr. D. CAMERON read a paper "On Instances of Frogs said to be found alive in Solid Rock;" but the Meeting generally did not agree with the author's conclusion—that some of the alleged instances were authenticated.

1st FEBRUARY, 1877.

Mr. JAMES DAIRON, *Vice-President*, in the Chair.

Messrs. Thomas Hill and John Buchanan were elected Ordinary Members.

Mr. THOMAS KING read a paper, entitled "Description of a Dry River Bed in the Desert of Atacama, North Chile." (See page 18.)

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In the course of a discussion which followed, Mr. JOHN YOUNG, F.G.S., stated that the causes which might have led to the drying up of the old river channel might have arisen from several causes, such as the cutting down of the forests, changes in the physical configuration of the land, or in the absence of water-laden clouds which once precipitated their moisture on the mountains. It was, however, probable, as Mr. King suggested, that the river valley had yet water flowing through it in some of the rainier seasons. If so, then the valley might still be undergoing a gradual process of deepening and widening. Only during flood seasons was there any great work done by rivers in scooping out their channels. The origin of the salt marsh might have been from the river having at one time flowed into a lake or swamp, and if the evaporation was nearly equal to the precipitation in a hot, dry climate, then it was probable that mineral salts, dissolved out of the rocks by the action of water, had been deposited in the marsh along with other sediment carried there by the river. All salt lakes in the world derived their saline materials from the adjacent rocks, and were always found in those regions where the evaporation and precipitation were evenly balanced, or nearly so.

Mr. YOUNG then spoke at some length upon Slaty Cleavage, as illustrated by two slates from Kilaloe, Ireland, which had been presented to the Hunterian Museum by Mr. Hugh Macphail. In these slates, which were of a dark grey colour, the original lines of stratification were very distinctly marked in the form of bands of a darker shade than the body colour, and running across in straight lines. These coloured bands varied from ¼ inch to 1½ inch in breadth, and in some of the broader bands from 12 to 15 alternating layers of sediment could be counted. The slates were hard and fine-grained and free from crystals of iron pyrites. The cleavage was at right angles to the lines of stratification, and apparently large slates could be easily got from the parent rock. As the sediments which formed our Scottish slates are nearly of uniform colour within the breadth of a slate, few of them showed any of the original lines of stratification, and it was not easy to tell the angles of cleavage, but in these Irish specimens, the case was different, the lines of stratification indicating very clearly the angle of cleavage in the bed. Mr. Young referred to the theories which had been advanced to explain the phenomenon of cleavage in fine-grained, argillaceous, sedimentary rocks, such as heat and pressure, chemical and electrical forces, &c., but he believed the causes were not yet clearly understood.

22nd FEBRUARY, 1877.

SPECIAL MEETING.

In the Corporation Galleries, the President of the Society, Sir WILLIAM THOMSON, F.R.S., delivered the Annual Presidential Address before a large audience, the subject being "Geological Climate," and more particularly referring to the recent discoveries in the Arctic seas. (See Vol. V., Part II., page 238.)

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Mr. DAVID SANDEMAN, *Vice-President*, moved a hearty vote of thanks to Sir William Thomson for his able and interesting address, which was cordially agreed to.

8th MARCH, 1877.

Sir WILLIAM THOMSON, *President*, in the Chair.

Mr. John Rhind was elected an Ordinary Member.

Dr. JAMES THOMSON, Professor of Engineering in the University of Glasgow, read a paper, entitled "The Jointed Prismatic Structure of Basaltic Rocks." (For a full abstract see page 95.) The paper was illustrated by an extended suite of drawings and specimens.

Discussion upon the paper having been invited by the Chairman,

Mr. JOHN YOUNG, F.G.S., V.P., stated that the spheroidal structure observed in the weathering of certain trap rocks, chiefly doloritic greenstones, was due more to the mineral composition of this variety of trap than to any spheroidal arrangement in the rock mass itself, which formerly was supposed to have taken place when it was cooling. In the trappean districts of Western Scotland, he had often observed that only those dolorites containing iron oxides and sulphide of iron in their composition, exfoliated under the influence of the atmosphere in concentric rings or layers; it was a phenomenon seldom or never observed among the traps of the felstone group, which, as a rule, contain little or no iron. The dolorites which weather into these concentric masses are found both in the form of intrusive dykes and beds of trap lying amongst our sedimentary strata, but it is only when such igneous rocks are exposed to the influence of the weather that they show the spheroidal form under their decay. These doloritic rocks near the surface of the land are seen to be traversed by fissures in all directions, which break up the rock into irregular-shaped masses. When in their natural position, it is easy to see that this spheroidal system of weathering has proceeded from the outside of these angular masses inwards, in a series of more or less concentric layers, the unaltered kernel of rock in the centre of each mass becoming more and more rounded or boulder-shaped as the weathering proceeds. Mr. Young referred to the rock composing the mass on the north-west face of Stirling Castle, and to other masses of similar dolorite over the country, as affording excellent examples of this concentric form of decay, and stated that such was not peculiar to the doloritic traps, but was to be observed also in boulders of certain ferruginous sandstones and clay ironstones found lying in our surface soils. He believed, therefore, that it was more to the oxidation of the iron in these rocks from the action of the atmosphere rather than to any previous spheroidal structure in the rocks themselves, that this concentric method of arrangement seen under decay is due. With regard to the columnar traps in the districts around Glasgow, he had never seen any examples which would lead him to infer that their columns had assumed their present form through the pressure of spheroidal masses against one another in cooling from the

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liquid condition. We have perfect columnar structure developed in certain coals, sandstones, and other sedimentary rocks which have never been fluid. Columnar structure in nearly all rocks is chiefly due to the contraction of the mass from a more highly-heated condition during cooling, and he quite agreed with Professor Thomson in considering that the cross fracturing observed in columnar trap is secondary to the formation of the columns themselves. In some columnar traps that he had examined he found that the columns had been cracked across at very irregular distances, and often in a most uneven manner.

Mr. E. A. Wünsch, F.G.S., said that no geologist of the present day, whose opinions were based upon actual observation, and not upon extracts from antiquated text-books, would maintain that the columnar structure of basaltic rocks and the exfoliation of the same rocks in concentric layers had their origin in one and the same cause. This theory of internal concentric rings was first advanced by Gregory Watt in 1804, and has since been propagated from one text-book to another. Professor Thomson had therefore rendered a service to geological science in once more exposing so conclusively as he had done the groundlessness of the theory. To account for exfoliation in basaltic rocks we simply require the presence of iron and the access of atmospheric air or water, and it would follow as a matter of course that the outer oxidized portions of the rock would peel off in concentric layers, no matter whether the shape of the rock was columnar or otherwise. With regard to columnar structure, all that could be said was that it was due to shrinkage. It had been shown that granite, in cooling, shrinks ten per cent., and a German geologist, Professor Mohr, in his "History of the Earth," not yet translated into English, advances the view, based on chemical grounds, that specular iron, as contained in most basaltic rocks, is gradually converted into magnetic iron, and is thereby reduced in volume nearly one-half—the exact proportion being 45·8 as to 22·4—and this would be sufficient to account for a considerable shrinkage in basalt. But Professor Thomson had shown that a similar columnar structure was produced in starch, clay, coal, and other substances, and must, therefore, be due to a general mechanical law, the elucidation of which might fall more within the province of their learned President than of geologists pure and simple, who confine themselves to describing actual appearances only. That the joints or cross fractures were formed subsequently to the longitudinal fractures had been shown conclusively by Professor Thomson, but whether the cause for this had to be sought for in water gaining access to the columnar joints, seemed to him doubtful, for all who knew Staffa and the Giant's Causeway, or who only carefully examined photographic views of these places, would observe that all basaltic masses showing columnar structure were topped by a layer of confused rubble, consisting in reality of what he held to be incipient cubes and columns irregularly disposed, but sufficiently dense to prevent water from penetrating to the regularly formed columns below. He would therefore feel inclined to ascribe the cross fractures to the same cause which had formed the longitudinal division of columns, rather than seek for them a new and extraneous cause, such as the percolation of water.

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Mr. D. C. GLEN, F.G.S., and Mr. JAMES NEILSON, jun., also made some remarks upon columnar structure, after which a cordial vote of thanks was passed to Professor Thomson for his interesting paper.

12th APRIL, 1877.

Mr. JOHN YOUNG, F.G.S., *Vice-President*, in the Chair.

The following gentlemen were elected Members of the Society:—as Life Member, Dr. Henry Muirhead; as Ordinary Members, Messrs. J. C. White, R. M. Müller, C.E., A. Gillespie, Geo. R. Hislop, F.C.S., Thos. L. Wilson, Alameth Coulthurst, Mathew Blair, Thos. Severn, Robt. Mathieson, S. W. Robinson, Wm. Maclay, John M. Campbell, Robt. Balloch, Thos. Kincaid, Wm. Ferguson.

Mr. D. C. GLEN, F.G.S., exhibited a number of specimens of minerals collected by Mr. Albert Smith, C.E., when superintending engineering works in the province of Rio Grand do Sul, Brazil. Amongst these there was a remarkably fine example of a geode of chalcedony containing water, a circumstance of very rare occurrence, and called by the natives "lapis d'agua" or water-stone. The crystal measured 3½ by 2¾ inches, and about ¾ of an inch in thickness, thinning off towards the edges. It was quite transparent, and the skin or shell appeared to be about one-tenth of an inch thick. When laid on its flat side the bubble or air cavity appeared to be 1 inch in diameter. The outer surface on both sides showed the beautifully mammilated and wavy or curly appearance often present in chalcedony. This specimen was found in the bed of the River Jaguaron, about 300 miles south of the St. Jeronomo coal mines, the enclosing matrix having been a light grey volcanic rock, similar to that found in the trap at Bishopton Tunnel, though it had, in this instance, been all worn or weathered off. In the same locality, and for several hundred miles to the north, the formation consists of sand, gravel, and small rounded pebbles and boulders up to about 12 inches diameter in their longest axes. These when broken sometimes contain a cavity lined with crystals of quartz, calcite, fluorite, &c., and sometimes filled with clear fresh water. Unfortunately, in the present instance, and in similar specimens which Mr. Glen had heard of, the chalcedony does not appear to be impervious, the contained water therefore escaping by imperceptible degrees, as has been ascertained by repeatedly weighing the specimens. He had therefore taken the precaution of keeping his specimen immersed in water. Similar druses or cavities are not uncommon, especially in volcanic formations, and are usually lined with fine crystals of various kinds. If the whole lining happens to be weathered out or broken out entire, it is not unlike a potato in appearance, and is popularly known as "potato-stone." Many of our "Scotch pebbles" are portions of the lining of such cavities in volcanic rocks.

Mr. GLEN also exhibited a specimen of conglomerate containing a small diamond, from the province of Minas Geraes, where the Brazilian diamonds

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are mostly found. It was part of what the miners call a reef, which occurs amongst the gravel where the diamonds are collected, and consisting of black and white rounded pebbles cemented by a ferruginous matrix; when found it is broken up, and washed with the gravel, for the brilliants. Mr. Glen also showed several specimens of copper ores, consisting of blue and green carbonates, a ball of blue earth impregnated with copper, specimens of rich magnetic and micaceous iron ores, all showing the great mineral riches of the comparatively little known country from whence they were brought.

Mr. JAMES THOMSON, F.G.S., exhibited two new species of Carboniferous corals, and made the following remarks:—The genus to which the first species that I put before you to-night belongs is *Alveolites* of Lamarck. Its generic characters are, corallum composed of closely aggregated prismatic cylindrical corallites, more or less arranged in superimposed concentric layers, and usually found in hemispherical masses, pyriform, and in large flat sheets. The calices are hexagonal, occasionally pentagonal, or heptagonal. Septa are awanting, and are represented by one tooth-like projection. The tabulæ are complete. It increases by fissipariety, and the divisional walls arise from the tabulæ, and are about ⅓ of the diameter of the calice from its margin. Milne Edwards and Jules Haime's "Monograph of British Corals, 1850," records two species of *Alveolites* as occurring in the Carboniferous limestones of Great Britain, viz., *A. septosa*, and *A. depressa*, and regards *Favosites capillaris* of Phillips as merely a synonym of *A. depressa*. Sedgwick and M'Coy, in their "British Palæozoic Rocks and Fossils," regard the corals of this group as belonging to the genus *Chætetes*, and record two species, *C. capillaris* and *C. septosus*. I have discovered an intermediate form, which in structural character agrees with the descriptions of *Alveolites depressa* given by these authors. I have likewise to add another species, which differs widely from either of the above, and appears to be altogether new. This I discovered in Blackridge Quarry, Dumfriesshire, in July, 1876, and I have since found another large example at Nether Burn, Muirkirk. When in Edinburgh lately Mr. Robert Etheridge, jun., of the Geological Survey of Scotland, showed me a beautiful specimen of the same species, which was collected from Cat-Craig, near Dunbar, by Mr. James Bennie, also of the Survey. I propose to name it *Alveolites Etheridgei*, and add the following description of it:—Corallum irregularly hemispherical, corallites irregularly hexagonal, pentagonal, and sub-rhomboidal, calices minutely granulated around the inner margins, diameter one to two in the space of a line, tabulæ seven in the space of a line. Found associated with *Productus giganteus*. It is in the size and form of the calices that *A. Etheridgei* exhibits its distinctive peculiarities; as also in having the inner margin of the calice minutely granulated sufficient to warrant the creation of a new species.

Mr. THOMSON then described what he believed to be the generic characters of the genus *Zaphrentis*, and noted the differences between it and *Amplexus* on the one hand, and *Cyathophyllum* on the other.

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He then described the structural details which characterized the species which he now proposed to establish, and which in honour of its discoverer, Mr. John Smith of Eglinton Ironworks, Kilwinning, he had named *Zaphrentis Smithii.*

Mr. DAVID ROBERTSON, F.L.S., F.G.S., read a paper "On the presence of Hermit Crabs in the Post-tertiary Clays of the Clyde Basin." (See page 23.)

Mr. DANIEL WILSON then read a paper entitled "On certain Geological Features of the Lower Portion of the Clyde Valley." In it he described the salient features to be seen along both shores of the Firth from Dumbarton downwards, noting particularly the enormous changes that had taken place, owing to the alterations in the sea-level and the effects of denudation by water and ice.

26TH APRIL, 1877.

Mr. DAVID SANDEMAN, *Vice-President*, in the Chair.

Messrs. Robert Hamilton, Thomas Whitelaw, Peter Cameron, Alexander Kyle, M. M. Graham, William Leck, Gavin Pratt, W. D. Gordon, George Coulman, and J. S. Russell, were elected Ordinary Members.

Mr. ARTHUR PRATT exhibited specimens of a pale yellow Fluorite in connection with calcite, from West Broadstone, Beith, where it is found in fissures of the limestone. The only other recorded locality in the West of Scotland is Kempock Point, Gourock, where it is found, with other minerals, lining the interior of geode cavities in the trap rock.

Mr. PRATT also showed a specimen of Millerite from the Broadstone Quarry, where it was found accompanying the Fluorite in the form of minute capillary crystals of a golden yellow colour—the only other locality in the West being Dockra lime quarry, also in the Beith district. Mr. John Young, F.G.S., and Mr. D. C. Glen, F.G.S., spoke of the interest attached to the discovery of these two minerals in the West of Scotland, and pointed out the importance of paying close attention to the linings of fissures, and other cavities in rocks, as likely to result in the discovery of other minerals new to the district.

Mr. THOMAS NAISMITH exhibited a number of fine specimens of Carboniferous fossils from the neighbourhood of Glasgow, some of which were briefly described by Mr. Young.

Mr. DAVID ROBERTSON, F.L.S., F.G.S., read "Some Additions to the lists of Fossils from the Garvel Park Post-tertiary deposit." (See page 57.)

Mr. JAMES THOMSON, F.G.S., read a paper entitled "Notes on the Cambrian Rocks of Loch Broom, Sutherlandshire," which was followed by a discussion, in which several of the Members took part.

18th MAY, 1877.

Mr. JAMES DAIRON, *Vice-President*, in the Chair.

Mr. JOHN YOUNG, F.G.S., gave an interesting description of Callander and its vicinity, the locality of the Queen's Birthday excursion of the Society.

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PROCEEDINGS FOR THE SESSION 1877-78.

11th October, 1877.

Mr. John Young, F.G.S., *Vice-President*, in the Chair.

The Chairman, in opening the first meeting of the Session, congratulated the members upon once more assembling for a new campaign, and hoped that the work of the year would not yield the palm in value to that of previous years. The Society was now in a favourable position as to membership, which, however, he hoped would still be increased.

Mr. Thos. Naismith exhibited specimens of a red breccia, containing a profusion of bones of antelopes, or allied ruminants, as was clearly shown by the jaws with teeth, which were perfectly characteristic of that group of mammalia. The breccia had been imported from Greece for the purpose of making artificial manure, which, from the abundance of the contained phosphates, it was well suited to do. The Chairman said it would be very interesting to learn whether the deposit was of any extent, or whether it occurred merely as a red cave-earth, in which case it would be comparatively limited in quantity. It bore a great resemblance to the red cave-earth of the British bone-caves, such as Kent's Cavern, near Torquay, and the Victoria Cave, at Settle, in Yorkshire. He hoped that Mr. Naismith would be able to bring forward some further information on this point. Mr. M'Phail and Mr. Mayer also made some remarks on the subject.

Mr. Naismith also exhibited a large series of plant remains, principally ferns, which he had collected within a radius of five miles round Glasgow, and from four different pits—Tollcross, Foxley, Mount Vernon, and Glenduffhill, the depth of the strata from which they came varying from 55 to 70 fathoms. The shale in which they are principally found lies above the Kiltongue coal, which covers a large area of the Clyde Valley, and is named from having been first found at a farm-house so-called near Airdrie. The genera represented were principally *Alethopteris*, *Sphenopteris*, and *Asterophyllites*. Mr. Naismith further spoke of the formation, age, and distribution of our coal deposits, and concluded by giving the *modus operandi* for finding and securing specimens similar to those he exhibited.

After some remarks by the Chairman and Mr. Coutts upon questions raised in Mr. Naismith's paper,

Mr. John Kirsop exhibited some fine specimens of fern fronds on slate, from the Col de Balme, Switzerland, and read the following remarks.—"When visiting the marvellous Gorge de Trione in the valley of the Rhone, this summer, I remarked that the gatekeeper had on his stall three slabs of slate containing fern impressions. I was much struck with these, and acquired them. In all the Continental museums I visited, I kept a look out for similar specimens, but saw nothing resembling them, nor did I

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find anything corresponding to them in the Geological Museum, Jermyn Street, London, to which I paid a hurried visit on my way home. I then sent one of my slabs to Professor Ramsay, who referred it to Mr. Etheridge. He informed me that they had no British specimen to compare with it, and identified the fern as belonging to the genus *Odontopteris*, the rock being probably highly altered Lias. Afterwards, through a friend, I sent this specimen to Mr. Woodward, of the British Museum, who not only showed him many Continental examples presented to the Museum by Mr. Alfred Wills, but gave him much information on the subject, and said that by the most eminent authorities the rock was now believed to be Carboniferous. Since that time, I find that a paper was read by Sir Charles Bunbury, before the Geological Society of London, in November, 1848, on fossil plants from the Anthracite formation of the Savoy Alps. The author speaks of these plants as one of the most curious anomalies, geologically speaking, to be met with, and states that M. de Beaumont, in a paper published in the *Annales des Sciences Naturelles* in 1828, announced that near the Valley of Petit Cour, near Montiers, in the Tarentaise, he had found beds of black schist, abounding in impressions of ferns and other plants, identical with those of the Coal formation, and that they were interposed between beds of argillaceous limestone containing belemnites. As he was quite satisfied that they really belonged to the same geological epoch, he referred them to the Lias. This paper was followed by one from M. Adolphe Brongniart, who enumerated nineteen different species of plants, seventeen of them being identical with Carboniferous ones. In a subsequent paper M. de Beaumont described a series of strata of vast thickness which occurs in the Alps, between Briançon and St. Jean de Maurienne, and which he spoke of as belonging to the same system as the beds previously referred to in the Tarentaise. In 1844 the Geological Society of France met at Chambery, where their attention was directed to the fact that the strata containing ferns really alternated with those containing belemnites, both evidently belonging to the same formation, and they therefore quite confirmed the conclusions arrived at previously by M. de Beaumont. In 1846, Mr. Horner, President of the Geological Society of London, called the attention of English geologists to this subject. On examining the fossil plants of the Tarentaise, he had found considerable difficulty in arriving at any satisfactory conclusion, owing to the fact that, though numerous, the remains of plants were, in general, very imperfect. They were often, also, coated with a silvery white talc which, though giving them a beautiful appearance, interfered with the more delicate and minute markings. Above all, the fronds of the ferns were frequently distorted in a most irregular manner, either in consequence of drifting or crystallization, which perhaps accompanies the upheaval of the slate. Mr. Horner stated that Sir H. de la Beche was the first to record the occurrence of fern impressions in the schistose rocks of the Col de Balme, and also to notice their close resemblance to those of Carboniferous age; but that no belemnites, nor any animal remains whatever, were found. De Beaumont considers these slates belong to the lowest part of the Lias, as they are the lowest fossiliferous

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rocks of the district where they are found, and rest immediately upon crystalline talcose schists, which pass downwards into the gneiss and protogene, which build up the mountains on both sides of the valley of Chamounix. In another paper by Sir Chas. Bunbury on a remarkable specimen of *Neuropteris*, he mentioned, that since his former communication was read to the Geological Society, he had had the opportunity of examining some additional specimens from this Alpine Anthracite deposit, and from a different locality, and that all of them, in a state fit for examination, belonged to forms elsewhere characteristic of Carboniferous plants, while there was an entire absence of all the characteristic Jurassic forms. He said that until this apparent anomaly was satisfactorily explained, we cannot safely rely on fossil plants as certain indications of the age of any formation.

This paper was followed by an interesting discussion upon varieties of so-called Slates, their ages and formation, the Chairman remarking that all slates properly so-named were products of metamorphism.

Mr. ARTHUR PRATT exhibited specimens of garnetiferous schistose rocks, which he had lately found on the banks of the river Orchy and in adjacent localities, and said that any one who visited the famous parallel roads of Glenroy would see any quantity of garnets amongst the schistose rocks of that district, although none of them were commercially valuable, being all more or less in a shattered condition.

Mr. JOHN YOUNG, F.G.S., read a paper entitled "Notes on the Limestone strata of the District around Glasgow, and their Fossil Contents," illustrating it by typical specimens. (See page 29.)

1st NOVEMBER, 1877.

ANNUAL GENERAL BUSINESS MEETING.

Mr. JOHN YOUNG, F.G.S., *Vice-President*, in the Chair.

Messrs. Bryce M. Wright, F.R.G.S., and Thos. A. Grant, were elected Ordinary Members.

The SECRETARY then read the Annual Report of the Council on the work of the past Session, as follows:—

The Council beg to submit to the Members of the Geological Society of Glasgow their Report of the past Session, 1876-7.

MEMBERSHIP.—The number of Ordinary Members on the roll is 224, showing a considerable accession, a state of matters which must be very gratifying to all.

The Council would at the same time point out that there is still room for increase in the membership, and that every additional name means more power for work. They therefore hope that Members, especially those more lately joined, will enlist their friends in the cause of the Society.

LIFE MEMBERS.—The Life Members now amount to 21, and this list is capable of indefinite extension, the proceeds being held strictly in reserve

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as a contingency fund, which it is hoped may never be required, but the interest of which as it grows will help to render the Society independent of fluctuations in its income from accidental causes.

ORDINARY MEETINGS.—These have been on the whole well attended, the interest having been kept up by a number of excellent papers, while very many interesting specimens have been brought forward from time to time. As in former years, the Council wish to point out the fact that a comparative few of the Members contribute either papers or specimens, a state of matters which they would gladly see altered, as many must have matters of Geological interest to communicate, and which, they may be assured, will always be received with respect. There were no special lectures during the Session, those of the Science Lectures Course in the City Hall, and those of Mr. John Young at the Mechanics' Institution, having obviated the necessity for any others on the part of the Society.

EXCURSIONS.—The localities visited during the season were as follows:—14th April, Gourock, conducted by Mr. D. Wilson; 28th April, Barrhead and Gleniffer, by Mr. D. C. Glen, F.G.S.; 12th May, Auchentorlie and Auchenreoch Glens, by Mr. John Young, F.G.S.; 24th May, Corrieburn, afterwards altered to Callander, by Mr. John Young, F.G.S.; Bathgate, by Mr. James Thomson, F.G.S. They were well attended, and thanks are due to the conductors.

LIBRARY.—The Library has been to some extent made use of by the Members, although not so largely as in some former years, partly from the want of accommodation, and partly that no new books except those sent by Societies have been added for some time. The Council hope, however, that the improvement in the funds of the Society will extend itself to the Library, and that some of the recent high-class works may be added shortly. Applications for exchanges of publications continue to be received from some of the Continental Societies of high standing—a proof of the estimation in which the *Transactions* of your Society continue to be held.

TRANSACTIONS.—Part 2 of Vol. V., containing the *Transactions* and *Proceedings* of two years, is now all in the printer's hands, and the Council have no doubt that it will be ready for distribution at or before the next meeting. This part will contain, amongst other papers of interest, the important address by the President, Sir Wm. Thomson, on Geological Climate, delivered last February, and which will be illustrated by a handsome Map of the Polar Mediterranean Sea, specially prepared for the Society by Messrs. W. & A. K. Johnston of Edinburgh.

PLACE OF MEETING.—Though some considerations led to proposals being made for a change of the place of meeting, the Council resolved to remain in Anderson's University (now College) for another Session, their reasons, amongst others, being the difficulty of getting a suitable place of meeting at anything like a moderate rent, the uncertainty as to the effect of any change on the well-being of the Society, and the trouble and expense of removing the Library and Museum, and other property. At the same time a small committee has been appointed for the purpose of keeping the question constantly in view.

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DEATH OF MEMBERS.—The Council would express their deep sense of regret at the sad accident which deprived the Society of one of its oldest honorary associates and esteemed friend, Dr. James Bryce. Dr. Bryce, a Scotchman by descent, was born in the north of Ireland, becoming, however, a student of Glasgow University, where he took distinguished honours. Before he was thirty years of age he became Mathematical Master in the High School of Belfast, whence, in 1844, he came to Glasgow to assume the position of Mathematical and Geographical Master in the High School, then vacant by the death of the accomplished Dr. Connel. Here he remained until 1874, when he retired from his profession, and went to reside in Edinburgh.

From his long residence in Glasgow, and the prominent position he held in connection with the Philosophical Society, Dr. Bryce was well known, and in Edinburgh he took an active share in the work of the Royal and Geological Societies. Connected with this Society since 1860, he did not put much before its meetings, although the number of his published papers on scientific subjects, especially Geology, is large. He was the author of various works, his best known being perhaps that on the Geology of Arran and Clydesdale, which has gone through several editions.

Before leaving Glasgow, Dr. Bryce presented to the Society a large number of specimens of rocks and fossils, principally from Skye and the North-west Highlands, and also many Geological Maps and Sections of value.

It may be in the memory of a number of the Members that some years ago, on the occasion of an excursion by the Society to High Blantyre, the scene of the late dreadful coal-pit explosion, Dr. Bryce made open house to the Members, and, after their day's work, entertained them in right hospitable fashion.

Though not directly connected with the Society, the Council cannot allow this occasion to pass without expressing their sense of another loss to the scientific world, in the sudden death of Mr. William Keddie, who was also well known and universally respected in Glasgow, with which he had been connected all his life. Editor of the *Scottish Guardian* newspaper during almost the whole term of its existence, Mr. Keddie afterwards took up the position of a Scientific Lecturer, latterly becoming Teacher of Science in the High School, and more recently Professor of Natural Science in the Free Church College. He was also for thirty years Secretary to the Philosophical Society.

A man of the most genial and kindly disposition, he was held in high esteem by all who had the pleasure of his acquaintance.

Mr. Keddie contributed the admirable sketch of Dr. Scoular, extending to 12 pages, which appeared in the Society's *Transactions*. (Vol. IV., Part II.)

In both these cases the Council propose, with the approbation of the Members, to send a short note of condolence, as a mark of respect and esteem, to Mrs. Bryce and to Mrs. Keddie, who both survive their husbands.

Death has also claimed several of the older Members of the Society since last year, among whom may be mentioned Mr. John Yuille, Carlton Place, and Mr. Henry M'Donald,, whose well-known faces have been regularly seen at the Meetings and Excursions of the Society for many years.

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The Treasurer then submitted his Annual Statement (abstract appended, page 155], which showed the financial state of the Society to be very satisfactory.

The undernoted gentlemen were elected to fill the vacancies amongst the Office-bearers occurring at this time:—Mr. David Sandeman, Vice-President; Messrs. A. Pratt, Robt. Mason, Joseph Somerville. Jas. Somerville, Members of Council; Mr. John Wight, C.A., Treasurer; Mr. Richard Neilson, Librarian; Mr. James Barclay Murdoch, Secretary; Mr. John Burns, Joint-Secretary; Messrs. D. Cameron and James White, Auditors.

During the evening the Chairman read a paper by Mr. James Stewart on Whale Remains found in the Carse of Stirling. (See page 49.)

Mr JAMES ALLAN exhibited a mass of fibrous Asbestos, containing an aggregation of crystals of beryl, which showed in daylight a brilliant green colour. It had been imported from Genoa.

6TH DECEMBER, 1877.

Mr. JAMES DAIRON, *Vice-President*, in the Chair.

Dr. Macalister, Messrs. Henry C. Young, William Renison, A. B. Dick-Cleland, Hugh Smith, C. J. Kerr, and Robert T. Moore, were elected ordinary Members.

Mr. DAIRON exhibited a number of specimens of Retiolites, which he had recently obtained from the Moffat shales, and on which he had read a paper. (See page 51.)

Mr. JAMES THOMSON, F.G.S., and Mr. JOHN YOUNG, F.G.S., made some remarks upon the subject, the latter observing that since the investigations of late years had been begun, a flood of light had been thrown upon the relations of the Moffat shales. Mr. Lapworth, of St. Andrews, had been able to point out that the first issue of the Geological Survey observations was completely wrong, as it went wholly upon physical evidence, while now the authorities were endeavouring to correct their previous mistakes by correlating the strata with the contained organisms. Only a week or two ago Mr. Lapworth read an interesting paper before the Geological Society of London on the great tract of Silurian strata in the South of Scotland. Professor A. C. Ramsay, Director-General of the Geological Survey of Great Britain, had taken some exception to Mr. Lapworth's remarks, but it was thought that on the whole he had clearly proved the position he had taken up. The Girvan shales were, he thought, an extension of the Moffat beds, the latter being less fossiliferous because they were formed in deeper water.

Mr. THOMAS NAISMITH exhibited and described a large slab of Coralline limestone, crowded with organisms, from Dunbar, and which had been cut and polished in Mr. Mossman's works.

Mr. J. THOMSON, F.G.S., made some remarks upon this very beautiful specimen, saying that he knew the district well from which the slab came. The parent stratum reached about two feet at its greatest thickness. The

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majority of the contained corals belonged to the genus *Koninckiophyllum*, though there were various other genera and species.

Mr. DONALD CAMERON read a paper "On the Origin of Garnets," illustrated by specimens in mica schist from Aberfeldy. Mr. Cameron gave an account of the composition of the garnet, as found both in Scotland and abroad, in its common and precious varieties, and also his own particular theories as to the causes of its formation. Mr. John Young, F.G.S., Mr. Glen, F.G.S., and Mr. James Neilson, jun., also made some observations.

Mr. DAVID ROBERTSON, F.L.S., F.G.S., then read a paper "On the Post-tertiary Fossiliferous Bed at the New Gas Tank, Paisley." (See page 53.) Mr. Robertson, in illustration of his interesting subject, showed a collection of the shells from the clay of the excavation, also a horn of the red-deer, which was of unusual size (see Plate I.), a slab of limestone, and a wing-bone of a swan, the latter showing that the locality had doubtless been the resort at one time of water-birds.

17th JANUARY, 1878.

Mr. DAVID SANDEMAN, *Vice-President*, in the Chair.

The Rev. A. S. Matheson and Mr. A. M. Findlay were elected Ordinary Members of the Society.

Mr. ROBERT CRAIG, Langside, Beith, exhibited a number of specimens of Carboniferous fossil fishes which he had obtained from the limestone strata of the Beith district. He stated that the beds which had yielded these remains lay in the Carboniferous limestone division of the coal-fields of Western Scotland. This representative of the Carboniferous or Mountain limestone of other countries consists essentially, in the West of Scotland, of a series of marine limestones, sandstones, and shales, alternating with strata of coal, ironstone, sandstone, and shale, which represent old land-surfaces, and fresh-water lake deposits. The fish remains are found in each of these two groups of strata, the ganoid fishes being almost exclusively confined to the fresh-water beds, while the remains of the selachian fishes are found in both series of strata, but are most abundant in the marine limestone. Mr. Craig briefly pointed out the several horizons of these remains, stating that some of the forms were confined to very narrow limits within the beds, while others had a more extended vertical range.

Mr. JOHN YOUNG, F.G.S., said that their friend, Mr. Craig, had been an enthusiastic collector for many years, and whenever any of the Members of the Society, or others interested in geological science, visited the district just described, he had been of invaluable assistance to them from his intimate knowledge of the strata and their fossil contents. Mr. Young then gave a short description of the more remarkable specimens shown by Mr. Craig, amongst which were an enormous fin-spine of a species of *Gyracanthus* and some of the massive cranial bones of the head of *Rhizodus Hibberti*, also a large crushing tooth of *Psammodus*. In this were united the specific characters of the two species of *Psammodus* described by Agassiz,

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P. porosus and *P. rugosus*. One half of the tooth was smooth and porous, while the other half was strongly rugose, so that there is little doubt of the fact being now established that these two species are in reality only one. The large shell-like palatal teeth in the collection, which were lying in a slab of limestone, attracted considerable attention. They measured in their greatest length 2½ inches, and were apparently lying in the same position to each other that they occupied in the mouth of the fish to which they belonged. They were of the genus *Pœcilodus*, and approached closely to *P. aliformis* of Agassiz, but were much larger than any specimens of that species found in our beds. Mr. Young pointed out that outside of the border of these teeth there lay one or two examples of the shark-like teeth of *Cladodus*, and stated that probably both forms of teeth belonged to the same fish. There were also shown examples of teeth belonging to the genera *Helodus*, *Chomatodus*, *Cochliodus*, *Tomodus*, *Psephodus*, *Xystrodus*, &c., beside some small undescribed fin-spines. It having been remarked that the Scotch Carboniferous beds contained very few fish remains compared with some of the Irish and English bone-beds, Mr. Craig said that he thought the scarcity was more apparent than real, and was probably owing to the more indurated state of the Scottish limestones.

Mr. James Neilson, jun., also exhibited a number of fish teeth and spines from the same district, and others from the Armagh beds, the latter greatly resembling those of Beith.

Mr. Arthur Pratt then read a paper on "Scottish Trap Rocks and their Crystalline Structure." (See page 58.) In illustration of his paper Mr. Pratt exhibited, under the microscope, a large and varied series of transparent sections of volcanic rocks, from the neighbourhood of Glasgow, and also from many other Scottish districts; also, a beautiful series of enlarged drawings, done by himself.

Mr. John Young, F.G.S., said that the subject on which Mr. Pratt had spoken was one of exceeding interest. Professor Zirkel had led the way, and Mr. Allport followed, but Mr. Pratt's labours in the same direction had been of no mean character.

Mr. Young then gave a short descriptive account of the dolerites, basalts, and other igneous rocks of the West of Scotland. After which Mr. D. C. Glen, F.G.S., said that the name of an old member of the Society, now removed by death, should be mentioned in connection with this subject, as being the first to bring the chemical analysis of rocks before the members, and also as showing specimens of them under the microscope. He referred to the late Mr. Wallace Young.

Natural Philosophy Class Room, University.

14th February, 1878.

Sir William Thomson, LL.D., *President*, in the Chair.

The Secretary read a letter from Mr. D. C. Glen, F.G.S., in which he presented a bookcase to the Society, and the thanks of the members were unanimously awarded to him for the generous gift.

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The chair having been taken by Mr. DAVID SANDEMAN, *Vice-President*, Sir William Thomson delivered an address on The Internal Condition of the Earth as to Temperature, Fluidity, and Rigidity (see page 38), illustrating it with many explanatory experiments.

7th MARCH, 1878.

Mr. JAMES DAIRON, *Vice-President*, in the Chair.

Mr. John Thomson was elected an Ordinary Member.

A communication from the Inverness Field Club was read stating that it was proposed to erect a memorial-stone to the late Dr. Bryce at the spot where he met with a fatal accident last year, near Inverfarigaig, and that it was hoped his Glasgow friends would contribute towards this object. Subscriptions were limited to five shillings. The Treasurer was appointed to take charge of a sheet for this purpose.

Mr. JOHN YOUNG, F.G.S., exhibited a series of specimens of well-crystallized Dolomites or Pearl-spars, obtained by Prof. Young and himself from the fissures in a limestone quarry of lower Carboniferous age, near Kirkcaldy, in Fifeshire, in the course of last autumn, whilst on a geological excursion through that part of the country. This Dolomite presents those curved faces in its crystals which are characteristic of this mineral species, as well as that of Ankerite and Siderite, into which it sometimes passes by changes in the mineral elements. It is of a white colour, with a very slight pink tinge when newly found, but weathers into an orange brown on exposure to the atmosphere, from the iron oxide, which is present, as shown by an analysis by Mr. J. B. Hannay, to the extent of 6·68, and which shows a passage of the mineral into Ankerite or brown Pearl-spar. Some specimens of the Dolomite are coated with large crystals of the hobnail form of Calcite, and of Blende, or Sulphide of Zinc, which seem to have been introduced by infiltration into the fissures at a later period. Mr. Young stated that his object, in exhibiting these specimens, was to point out their characters to the members, crystallized Dolomite not being a common mineral in the West of Scotland. The Felstone of Kempock Point, Gourock, is one of the few places where it is found. It there lines the cavities of geodes in the rock along with Fluor-spar.

Mr. JOHN KIRSOP exhibited a number of objects of interest dredged from the Clyde below Bowling, in the recent deepening operations, and kindly lent by Mr. Deas, C.E. Amongst them were segregations of sea-shells, cemented together by lime in a hard matrix of clay; portions of the vertebræ and caudal bones of a Whale, which came up from the Finlayston Bank, 14 feet below low water, being only the second or third example from the West Coast; a piece of oak, forming a portion of a canoe, and in as good preservation as when first used; also horns of red deer from the Finlayston Bank; these last being sent for exhibition by the daughter of the late Mr. Duncan, Engineer to the Clyde Trust.

Mr. JOHN YOUNG, F.G.S., read a paper on A New Scottish Mineral, Bowlingite. (See page 63.)

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Mr. MURDOCH then read a paper contributed by Dr. Lauder Lindsay of Perth, on "Australian Gold-quartz in Scotland." (See page 68.) Owing to the lateness of the hour, discussion on it was postponed till next meeting.

21st MARCH, 1878.

Mr. JOHN YOUNG, F.G.S., *Vice-President*, in the Chair.

Dr. GILMOUR was elected a Life Member, and Messrs. William Young and R. Watson, Ordinary Members.

Mr. DRON exhibited specimens of metamorphosed Carboniferous shale from the Lomond Hills, in Fifeshire, showing the action of volcanic rocks upon the surrounding strata.

The discussion on Dr. Lindsay's paper, held over from last meeting, was then taken up. The Secretary read a *resumé* of the subject by Dr. Lindsay.

Mr. GEMMELL, of Wanlockhead, son of the finder of the specimen referred to by Dr. Lindsay, read some remarks in reply. He entirely disputed both the facts and inferences of the paper, having no doubt whatever that the specimen was native gold-quartz. Mr. GEMMELL, senr., an old miner of Wanlockhead, was also present, and in some graphic verbal remarks corroborated his son's statement.

Several Members spoke on the subject, but the only fact of importance elicited was a remark by Mr. Gemmell, in answer to a question by Mr. Young, viz., that the specimen when found was quite weather-worn or water-worn, with no sharp or angular edges. The meeting unanimously came to the conclusion that Dr. Lindsay had not succeeded in establishing his case, the balance of proof being in favour of the native origin of the specimen.

12th APRIL, 1878.

Mr. DAVID SANDEMAN, *Vice-President*, in the Chair.

Mr. Thomas Stewart was elected an Ordinary Member of the Society.

Mr. JAMES THOMSON, F.G.S., laid on the table a monograph on the Carboniferous fossils of New South Wales, with an accompanying atlas of plates, presented to the Society by the author, Prof. de Koninck of Liége. Mr. Thomson said that a number of Prof. de Koninck's friends intended to subscribe for a bust of him in marble, to be placed in the hall of Liége University, and he, Mr. Thomson, would be glad to forward any subscriptions towards that object.

Mr. JOHN YOUNG, F.G.S., exhibited a sample of the mineral Vermiculite from Wodney Island, off the Lancashire coast, presented to the Hunterian Museum by Mr. Alexander Macgregor, Glasgow. This mineral belongs to the Margarophyllite section, and possesses the peculiar property of opening out into long worm-like threads by the expansion of the separate folia of the crystals when heated to 500 or 600 deg. F. This sometimes takes place with such force as to break the test tube in which the mineral is confined.

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Mr. YOUNG also showed a series of crystallized specimens of Calcite which he had collected from the Carboniferous strata of the West of Scotland. These exhibited some of the numerous crystalline forms which Calcite is known to assume. It was pointed out, that however various those forms may be, they were all based on the rhombic, which is the fundamental form in which carbonate of lime crystallizes.

Mr. D. C. GLEN, F.G.S., exhibited a specimen of Calcite from the Permian limestone of Sunderland, closely resembling the crystallized Fontainebleau limestone of France—in which a large quantity of sand or other impurity enters into the composition of the lime crystals, which in the above varieties assume the rhombic form.

Mr. D. C. GLEN then read a paper, entitled "Notes on the Varieties of Trap rocks found on the Coast of Ayrshire, near Largs" (see page 72). Mr. Glen's paper was illustrated by a number of tables, and by geological maps of the various districts spoken of, also a fine collection of rock specimens.

Several members having spoken on the subject, Mr. JAMES THOMSON, F.G.S., said that he had listened with much interest to Mr. Glen's paper, but that he could not agree with his conclusions as to the age of the volcanic rocks of the district spoken of. He did not think that any satisfactory solution of the question had yet been reached, but he hoped that the paper would call further attention to it.

26TH APRIL, 1878.

Mr. JAMES DAIRON, *Vice-President*, in the Chair.

Mr. James Christie was elected an Ordinary Member of the Society.

Mr. CHARLES LAPWORTH, F.G.S., of St. Andrews, read an interesting paper entitled "Recent Discoveries among the Silurians of South Scotland." (For a full abstract see page 78.) The paper was illustrated by a number of coloured maps and diagrams of the district under review.

Mr. JOHN YOUNG, F.G.S., in the course of some remarks, begged to congratulate the members present upon their having had put before them such an able paper as that of Mr. Lapworth's, and he thought that the views so clearly stated would carry conviction with them.

Mr. DAVID SANDEMAN, V.P., proposed that Mr. Lapworth should be elected an Honorary Associate of the Society, which was unanimously agreed to.

Mr. JAMES THOMSON, F.G.S., then recorded his discovery of three genera of Carboniferous Corals new to Scotland, upon which he read a few notes.

16th MAY, 1878.

SPECIAL MEETING.

Mr. JOHN YOUNG, F.G.S., *Vice-President*, in the Chair.

The Secretary (Mr. Murdoch) spoke of the arrangements made in connection with the excursion to Midcalder, arranged for Saturday, 18th inst., to

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meet the Edinburgh Geological Society. Mr. James Neilson, jun., gave some particulars of the district to be visited, followed by the chairman, who described the Burdiehouse limestone and other beds likely to be met with in the same neighbourhood. [For an account of the excursion, see page 146.]

Mr. Young then reviewed the strata likely to be seen at Craignethan Glen, on the occasion of the Queen's birthday excursion, 24th inst. [For an account of the excursion, see page 150. For Dr. Hunter's paper, see page 84.]

RECORDS OF EXCURSIONS.

KILLEARN.

Queen's Birthday Excursion, 24th May, 1874.

Within a short time after 9 A.M. the company, numbering between 80 and 90, began to assemble at St. George's Cross—the gentlemen generally with courier bags slung over their shoulders, containing some little provision for the day, and not a few of the ladies also with neat little baskets or reticules which could hardly be intended for bringing home fossils. All being settled in their places, three well-appointed omnibuses were speedily in motion along the New City Road—past the rows upon rows of new buildings which are fast joining Maryhill to Glasgow—past the new barracks, where the redcoats are busy at work—through Maryhill itself, flourishing amid its foundries, and gas-works, and collieries—then onward between the sylvan beauties of Garscube on the one hand and Killermont on the other, till in a short time the fashionable suburb of Bearsden was reached, and the old-fashioned but now reviving village of New Kilpatrick. Here, we are told, the Romans had a camp about 1900 years ago, and in some places the fast disappearing traces of the wall of Antoninus were pointed out by an obliging Jonathan Oldbuck of the company. Now, the moderns seem to be finding out the beauty and salubrity of the place, and handsome villas for the merchants, brokers, and lawyers of Glasgow are rising along the very line

> "Where Rome the Empress of the world,
> Of yore her eagle wings unfurl'd."

We speed on through a beautifully undulating tract of country—here passing a snug farm-house, surrounded by well-cultivated fields, and there an elegant mansion, "embosomed high 'mid tufted trees"—the road gradually rising towards the north-eastern termination of the Kilpatrick range of hills—till, immediately beyond Auchineden, at the "gap of the Lennox," it reaches the summit level of about 600 feet above the sea. Here we are fairly amongst moorland sights and sounds: the plaintive cry of the "peesweep" salutes the ear; the golden glory of the "whins" delights the eye; the birch and the "rowan tree," or mountain ash, with their fresh green leaves beautify

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the more sheltered nooks; and here, also, had the day been clear, a grand view would have been had of Lochlomond and "the Ben." But, alas, the *haar* of the east wind obscured all, and only a small part of the Loch was seen, with a few of the islands dimly descried, like shadows, or like pictures through a veil.

Instead of visiting the "Whangie," as we did on a former excursion to this neighbourhood three years ago, we pursue our route onwards to Killearn. But on the way down-hill we come to some quarries in the lower Carboniferous red sandstone, at Dhual glen. Vice-President Young leads the way, and, after a brief inspection of the quarry and of some slabs showing curious cracks and ripple-markings, he gives us a graphic sketch of the geological features of the district over which we have just passed. He tells of the "lower Carboniferous" strata of Possil, East Kilpatrick, and Duntocher, extending across by Johnstone, and so into the Ayrshire basin, by Beith and Dalry; of the "bedded traps" of the Kilpatrick Hills on the one hand, and the Kilbarchan Range on the other, shown, by the remains which have been found interstratified with them, to be also of the same age; and of the red sandstone rising to the north and west from beneath these volcanic rocks. The lower Carboniferous red sandstone in the West of Scotland seems to be singularly barren of fossils, but yields some good building-stone, as here and in the neighbourhood of Dumbarton. Mr. Young then sketches the lower and middle Old Red Sandstone and the Old Red of Dura Den in Fifeshire, both abundant in fish remains; and refers to Professor Ramsay's views as to the fresh-water origin of this ancient formation, confirmed by the fact that fishes closely resembling those whose remains it presents to us are found in the great Canadian lakes, and in some of the African rivers.

We now proceed on our way, but in a short time halt again to have a peep at Finnich Glen—so much of it, at least, as may be seen from the road. Beautiful exceedingly is the bright green of the overhanging leafy boughs contrasted with the deep red of the rocky chasm beneath. How long, O Geologist, has that little stream been in working out such a channel for itself? And, see, there it is still at work, fresh and untired, in summer and winter always at its appointed task, wearing down some portion of the rock, and carrying it away to form a soil elsewhere—constant and patient —"unhasting yet unresting"—as is all Nature!

But now we approach Killearn, beautiful for situation, and dignified by a monument, which we see rising before us, to brave old George Buchanan. Halting at Killearn, and stabling the horses for an hour or two, we adjourn to a field where we are kindly permitted to camp for a time, and here the baskets, courier bags, reticules, &c., are found to have been well worthy of their carriage. Then enthusiastic Buchananites go off to read the inscription on the monument; some take a stroll through the "toon;" a few amuse themselves with a rude imitation of "Aunt Sally;" while (and this was a great event) two of our "grave and reverend seigniors" actually undertake to test each other's speed of foot on a short course round one of the trees in the field. If Wordsworth thought it "no offence to reason" to deck his brows with the purple heather, why should a Geologist be

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ashamed of a little boyish frolic "on sic a day?" Does not science tend more than anything else to keep mind and body active, and the heart fresh and warm? Of course it does. So let our two friends have their race, while we look on, cheering and admiring and loving them both.

Rejoining our 'buses, we have a delightful afternoon drive past Dungoyne, and along the valley of Strathblane to Ballagan Glen. Here we again leave our vehicles, as we have arranged to spend some time in the Glen, and have tea. Messrs. Burns, Dairon, and Robertson, assisted by an active committee of ladies, see to the arrangements, while the other members follow their leader along the course of the stream, up the glen. The secretary of the Natural History Society, and a few other ardent botanists, who have kindly accompanied us, look out for some of their floral favourites; but the majority are chiefly interested in the famous geological section here exposed, known as the "Ballagan cementstone series of the Geological Survey." "Upwards of 230 beds of limestone, sandstone, and marly shale are seen lying tier upon tier, in a slightly inclined position, and capped by massive beds of whitish sandstone and trap, the whole presenting one of the grandest specimens of stratification to be witnessed in this country side." Mr. Young, whose monograph on the Campsie district, from which we have just quoted, forms the first part of the Society's *Transactions*, again favours us with a clear exposition of the geological place of the beds before us. He points out that they overlie the lower Carboniferous red sandstone of the valley of Strathblane which we have just left, and are overlaid in turn by the Carboniferous traps, and the lower Carboniferous limestone and coal of the Campsie valley. He reminds us that these beds form the base of the hills all around the Strathblane valley, and onward to the hills beyond Fintry, and that they also occur on the south-western flank of the Kilpatrick hills, in Auchenreoch and Dumbuck Glens, near Dumbarton, and also south of the Clyde, in the Greenock hills near Loch Thom. They may thus be regarded as the well marked base to this division of the Carboniferous system in the West of Scotland.

But a truce now to geology! We believe some one said something on the "glacial phenomena" of the district, but just then our attention was directed to a signal, which told rather of boiling than of freezing water—to wit, the signal that tea was ready. We rejoin the ladies in Nature's own drawing-room; "the cup that cheers" is handed round; a few complimentary speeches follow—"The Ladies;" "Vice-President Young," not forgetting the other V.P.'s, whose absence was regretted; "The Secretaries and Committee;" and "The Strangers," coupled with the name of a worthy Town Councillor of Glasgow, who made a graceful reply. These being duly honoured, and the echoes of the glen awakened with "Auld Lang Syne," we set out on our homeward way, and arrived at our starting-point shortly after 9 p.m.—thus completing the "round of the clock." And so ended a day, which in the memories of all who were of the company, must ever be marked with a white stone—QUARTZ: *lustre vitreous!*

B.

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RUMBLING BRIDGE AND CASTLE CAMPBELL.

Queen's Birthday Excursion, 24th May, 1875.

The members of the Geological Society of Glasgow are not exclusively closet students of the science in which they take such great delight, but, like all other true naturalists, they have a keen zest for meeting with and studying natural phenomena in the open air. Once a year they make an extraordinary effort, and allow their friends to join them and participate in their pleasures, the day selected for their scientific "outing" being the Queen's Birthday, on which occasion there is always a large turn-out, as sight-seeing and an agreeable pic-nic are usually conjoined with the more austere discussions which engage the scientific "stonebreakers" in their serious moods. Clackmannanshire was the county favoured on Thursday last. Altogether, there were probably not fewer than 150 persons in the party, a pretty large minority of which was composed of ladies. Two parties ought rather to be spoken of, inasmuch as well nigh 40 of the excursionists—a sort of advance-guard—left town by train from Queen Street Station very early in the morning, fully three hours before the main body set out.

The front of Rumbling Bridge Hotel was the point of rendezvous, and there was a goodly gathering of familiar faces at that beautiful spot. After friendly congratulations we descend leisurely, or with a rush, according to our tastes, into the glen occupied by the Devon—"the crystal Devon," and "the clear winding Devon" of Burns—where our guides explain the rock sections exposed to view at the waterfall, which is familiarly styled "The Devil's Mill." The erosive action of the water is described to us, as also the nature of the igneous rocks. Certain embedded bombs are pointed out as lying in a matrix of volcanic ash, and the processes of cooling and crystallization of the igneous rocks are also dwelt upon. Passing down the glen about 350 yards, we find that it becomes a deep and gloomy, but narrow chasm, which is spanned by a small arch, and which gives name to the spot now so famous in the romantic scenery of Scotland—"The Rumbling Bridge." Here, again, was a beautiful example of erosion. The impetus of the stream, in meeting an opposing mass of rock, gives the water a rotary motion, which is imparted to the sand, pebbles, and large stones carried down in flood, and these in their gyrations wear away the rock so as to form the potholes which form such a marked feature in the glen of the Devon. Descending the stream a little farther, places where the igneous rocks had been erupted through the lower members of the Carboniferous strata, or Ballagan series, were pointed out. After passing down the river for about a mile, over which the "even tenour of its way" is very slightly disturbed, we come to the Caldron Linn, which is in reality a series of linns. Here the river suddenly enters another wild, narrow chasm, and makes another series of falls. It rushes through the gorge with extraordinary power, and, striking against its sides, has, by its incessant action

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during unknown ages, worked out a series of gigantic caldrons. At length emerging, it falls over a precipitous rock in a beautiful cascade about 80 or 90 feet in depth, while the rock section exposed is probably more than a hundred feet high. Here, underlying the igneous rock, appear the lower members of the Ballagan series of strata, while overlying them there are probably the upper members of the same series.

Soon after reaching Dollar, the excursionists betook themselves to the glen, near the top of which stands the proud and stately pile known for centuries as Castle Campbell. The estate on which the Castle is situated became the property, some years ago, of the late Sir Andrew Orr of Harviestoun. It now belongs to his brother, Mr. James Orr, from whom permission was readily obtained to visit the castle and grounds.

Here several of the local residents were kind enough to accompany the excursionists up the glen so as to show them the points of interest. Among these may be specially mentioned the Rev. Dr. Barrack, the learned principal of Dollar Institution; Mr. Gibson, banker; and Dr. Strachan. Following the notes of one of these gentlemen, it may be stated that Dollar is said to have been derived from the Gaelic *doilleir*, which signifies *dark*, *sombre*, or *gloomy*. This opinion is founded on the well-known tradition which states that a daughter of one of the kings of Scotland—who resided at Dunfermline, then a royal residence—was, as a punishment for some wrong-doing, immured in one of the cells of the fortress now called Castle Campbell; and that while confined there she gave names to certain places and streams adjoining the Castle, corresponding to the depressed state of her mind at the time. The place of her confinement she named "Castle Gloom," and the hill on the east side of the Castle she called "Gloom Hill," a name which it still retains. To the two streams which glide past the east and west sides of the promontory-like knoll on which the Castle stands she gave the names respectively of "Burn of Care" and "Burn of Sorrow."

It is not known at what period the Castle was built, but it appears from title-deeds still extant that the Castle and lands came into the possession of the family of the Campbells of Argyll as far back as 1465. The titles state that "we give, all and haill, the third part of the lands of Dollar and Gloom in favour of Duncan Campbell, son of Sir Colin Campbell, Knight." Castle Campbell, or Castle Gloom, was a favourite residence of the Argyll family down to 1644, in which year it was consigned to the flames by the Earl of Argyll's deadly enemy, the Marquis of Montrose, who was not contented, it is said, with wreaking his vengeance on the proud castle of his feudal enemy, but that he also burnt, at the same time, every house in the parishes of Dollar and Muckart except two, the inhabitants being vassals of Argyll. John Knox stayed for some time at Castle Campbell prior to his return to Geneva, and it is frequently said that he administered his first sacrament in connection with the Reformed Church under the shadow and protection of the Castle. But that event really took place at St. Andrew's some years previously, and he likewise administered the sacrament in several other places in the west country prior to taking up his residence at Castle Campbell.

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Before leaving the Castle, one of the guides spoke of the igneous character of the range of hills (the Ochils) on which the ruined Castle stands, and described a felspathic porphyry which is seen to be erupted through the lower sandstones of the Carboniferous period, and which has thrown them up where they are exposed, at an angle of 41 deg. Farther up the glen was described another series of igneous rocks, consisting of amygdaloidal felstone. This was ejected through the stratified rocks during the deposition of the lower coal measures, and is in many respects similar to that found in the Kilpatrick and Bowling Hills, which reappears across the Clyde in the Bishopton Tunnel. Many boulders were found in what seemed to be a moraine—some of them local, while others belonged to the lower Silurian rocks, probably not found, *in situ*, nearer than the Grampians, one of them being 8 feet long by 4 or 5 feet broad, and of unknown thickness. There were also some whose structure suggested that they had been transported from the West Highlands. Another of the guides gave a short account of the great coal-field lying to the south of the Ochils, in the valley of the Forth, indicating the various strata in order of descent. A cordial vote of thanks was given to the gentlemen who had so kindly officiated as guides, on the motion of Mr. Kirsop, and responded to by the Rev. Dr. Barrack; and then the party descended the glen, and, under the guidance of the latter gentleman, inspected the institution over which he presides, and which is now famous all the world over as the Dollar Academy.

The party reached Glasgow about ten p.m., delighted with the day's excursion, rendered so enjoyable by the splendid weather fortunately prevailing.

J. M.

TOUCH HILLS AND STIRLING.

Queen's Birthday Excursion, 24th May, 1876.

The trip taken by the Society on the Queen's Birthday has come to be a popular feature of the excursion card. On this occasion, once a year, the members and their friends, choosing some locality interesting in a geological point of view, and attractive also from historic associations, make a day of it. Former gatherings have been conducted to such places as Killearn and Blane Valley, to the Finnich Glen and the Spout of Ballagan, to Craignethan (Tillietudlem) Castle, to Castle Campbell and the Rumbling Bridge. On Thursday last the district chosen was the town of Stirling, with a walk to Murray's Hall and the Touch Hills. Accordingly, at the Buchanan Street Station, before nine o'clock on the eventful morning, might have been seen groups of ladies and gentlemen, distinguished, amongst the crowds thronging that busy resort, by their bags, vascula, and baskets, with hammer heads or handles here and there protruding; and evidently on pleasure bent, by the anxious looks with which they regarded the somewhat lowering aspect of the morning. Tickets had been secured beforehand, and also carriage accommodation, so that there was no crowding for the former, or rushing

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after the latter, except in the cases of the few inevitably late ones, who perhaps had been canny enough to defer taking tickets until the day arrived and declared itself. The party, to the number of upwards of 120, comfortably bestowed in three of the company's most commodious carriages, and the train under weigh, conversation, merry or scientific, becomes the order of the day. The first portion of the Caledonian route to the North is through a most uninteresting country, so there is little to remark until Greenhill is reached, where the railway comes close upon the line of the Roman Wall, and the country becomes more attractive from its rolling hills and dales; its woods scattered on all sides, now just rejoicing in their young, rich foliage; and its fertile, cultivated fields. On the left, Larbert is soon passed—busiest of places at each Falkirk Tryst with dealers, drovers, cattle, sheep; then the ancient Torwood, where Wallace is said to have escaped his pursuers in the branches of a tree; then, still on the left, Bannockburn, dear in associations to every true Scottish heart; and in a few minutes we reach the busy, bustling station of Stirling. One cannot, unfortunately, be looking out of both windows of a railway carriage at one time, but those who did look to the right, saw, shortly after Larbert, the fertile Carse of Stirling, bounded by the imposing range of the Ochils, with Demyat rearing his crest as an advance guard; more to the front, the Abbey Craig, crowned by the Wallace Monument; and, nearer Stirling, the reaches of the Forth, with Cambuskenneth Abbey in the immediate foreground.

The platform having been reached, and greetings exchanged with numerous friends awaiting the arrival of the party, the Commander-in-Chief, Mr. John Young, F.G.S., issued the orders of the day. The Provost of Stirling had signified his intention of meeting the party, and of escorting it to Murray's Hall, but family bereavement had unfortunately prevented the carrying out of his purpose. In his stead, Mr. Hutton, a resident of the district and a member of the Society, gave welcome to the classic town, and afterwards led the party over the ground. By the thoughtful kindness of Mr. Glen, F.G.S., V.P., a huge wagonette had been provided for such of the ladies as preferred driving to walking. As soon as it was packed, a start was made, the drivers by the road, while the pedestrians took a short cut through the King's Park, and found themselves very soon skirting the edge of Colonel Murray's policies of Polmaise, and then rising across the front of the Gillies' Hill. Proceeding from this, the Sauchie burn was reached, and the walking party took its left bank, while the drivers proceeded up the road on the right bank, being separated from each other only by a few hundred yards. After an easy ascent a section was reached which showed the limestone overlaid by an enormous mass of trap, while the shale or sandstone coming in contact with the trap was highly indurated. Here, on the steeply-sloping grassy banks of the historic stream known as the Sauchie burn, and lower in its course as the Bannock, the party came to a halt, and attention to the inner man became the order of the day. In this matter also, Mr. Glen came to the front, and, from well-filled hampers, entertained a large number of the company in the most hospitable manner

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possible. Justice being done to the good things so amply provided, a muster was made on a grassy slope, where, in a brief, yet graphic way, the Society's guide, philosopher, and friend, Mr. John Young, F.G.S., gave an interesting account of the historical associations of the locality, and also of its more noticeable geological features. He stated that the district of country selected by the Society for the day's excursion, was one interesting to them as geologists from the varied phenomena presented by the physical aspects of the strata, in which could be traced clearly the combined action of fire and water at a former period of the world's history. To the unequal denudation from Carboniferous to post-glacial times of the two great classes of rocks, formed under igneous or aqueous conditions, we owe those peculiar features in the scenery of the district around Stirling which lend it such a charm, and which are characteristic of the trappean tracts of central Scotland wherever volcanic rocks prevail. But the neighbourhood is interesting besides to all who care (and who do not?) for the traditional and historical associations of their country. This has been the battle-field of Scottish independence. Within a radius of a few miles of the spot where they were now met no less than six great battles were fought within historic times, to say nothing of those fights whose memories have become matters of tradition, but which, undoubtedly, if fought at all, were fought here. The six battles of history are:—Stirling Bridge, A.D. 1297; Falkirk, 1298; Bannockburn, 1314; Sauchieburn or Field of Stirling, 1488; Kilsyth, 1645; Falkirk, 1746. Probably in no area of so small extent throughout the world have so many momentous conflicts taken place as within this portion of the shire of Stirling, and there can be very little doubt that the physical features of the district have had a powerful influence in the question. The narrow opening or gateway between the Ochil and Lennox ranges of hills was in early times the only route easily accessible to an army advancing from the southwards to the north of the Forth, the carse land of Stirling being then a morass, and frequently covered by the advancing tide, while the lowest ford on the Forth was at Drip, about two miles above the town of Stirling. The Castle of Stirling, perched on its rocky eminence, was the key that locked the passage through this gateway to the north, and its possession was almost equivalent to the mastery over the northern districts; hence it was a continual point of contest between those who held and those who wished to hold. There is no question that the physical features of a country impressed on it by geological structure have, as in this case, much to do in influencing its human history.

Mr. Young next pointed out the relation of the trap and other volcanic rocks to the sedimentary rocks of the district. He said that the traps which build up the Ochils are now known to be of Old Red Sandstone age, having been thrown up by volcanos contemporaneous with the water-formed strata of that formation. On the other hand, the traps which form the Lennox range, extending from near the town of Stirling to Dumbarton, did not begin to be poured out until from about the middle to the close of the calciferous division of the Carboniferous system of Scotland; these hills being therefore of later age than the

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Ochils. He then pointed out that there are in his neighbourhood several local areas of volcanic rock, occurring as isolated bosses and overlying masses, which apparently had been erupted in times later than the formation of the limestone strata which they break through and overlie. These trappean bosses form such rock masses as the Abbey Craig, Stirling Castle Rock, and Craigforth, while the overlying sheets form the lofty cliffs at Murray's Hall on the Touch portion of the Lennox range. These later traps are chiefly of the variety termed dolerite or greenstone, which occasionally assumes the columnar form, while elsewhere, as at the Castle Rock, it weathers into rounded masses known as concentric greenstone. At Murray's Hall the sections consist of various strata of Carboniferous limestone age, overlaid by a considerable thickness of trap. The limestone has been mined for a considerable distance under the trap, many of the workings being of old date, and it is still worked in the neighbourhood of Cambusbarron. Where the shale overlying the limestone has come in contact with the igneous rock it is seen to be highly indurated, and in it are found numerous small nodules of iron pyrites having a radiated structure, and which, no doubt, were formed by chemical segregation in the shale during its contact with heated matter. The Carboniferous strata dip from the Touch Hills towards the Stirling and Bannockburn coal-field, where higher members of the coal series have long been worked; some of the seams being of excellent quality.

Mr. Young concluded by referring to the history of the volcanic formations of Scotland, and of which this district affords many finely illustrative examples, remarking that the igneous rocks, being in most cases of a harder nature than the surrounding sedimentary strata, had more effectually resisted that great denudation which the whole face of our country has undergone, and of which these hills afford the standing monuments.

After a hearty round of applause to Mr. Young for his interesting address, the party retraced its steps down the little glen, and so gradually back to Stirling, enjoying on the way the magnificent views so lavishly displayed on every side. The town being reached, they proceeded to the base of the Castle Rock, to examine the sections of concentric greenstone and columnar basalt. Then reaching the esplanade, a guide was summoned, who explained the many interesting places and objects contained within the castle walls, not forgetting the Douglas room, where James II. stabbed the earl of that ilk, and which, no doubt, since the fire which lately destroyed it, is quite the same, only, like the Highlandman's gun, it has a new lock, stock, and barrel. The views from the castle battlements need not be here described. They are well known, but though old are ever new; and never did they appear to more advantage than on this afternoon, when the silver links of the Forth lay gleaming in their beauty, and the Perthshire Highlands loomed sharp and clear in the glory lent by the declining sun. A call was now made, as Freemasons say, from labour to refreshment, and never was food for the inner man done more thorough justice to than the spread so amply provided by mine host of the Royal Hotel. Nearly a hundred sat down; but time, tide, and trains wait for no man, so there was no time for talk. A hasty march was made for the station, the carriages reserved for the party

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were quickly filled, and soon after six the party were *en route* for home. Buchanan Street reached, the component parts of the gathering sped their various ways, happy to meet, sorry to part, and happy to meet again.

M.

GOUROCK.

14th April, 1877.

The first of the excursions for the season took place, as arranged, to the Gourock coast, and there was a large turnout of members, Mr. Daniel Wilson being conductor. The party proceeded along the shore as far as the Cloch Lighthouse, examining the sections of strata and the intrusive trap dykes seen cutting through the sandstone. The 25 and 40 feet old sea-beaches, marking the last rises of the land in Scotland, are well seen along this reach of the shores of the Clyde, the present road running generally along the 25 feet beach. The rocks, from Greenock downwards, belong to the basement beds of the Carboniferous system, according to the officers of the Scottish Geological Survey. Though formerly coloured in geological maps as Old Red Sandstone, it now appears that there is very little of this rock on either shore of the Clyde from Glasgow to Arran, the stratified rocks which here flank the Silurian hills of Argyllshire being, as formerly stated, of lower Carboniferous age, and forming the calciferous sandstone division of the system. These rocks consist of fine-grained sandstones and conglomerates, generally of a deep reddish colour. In some parts of the district the sandstone passes into reddish marly shales, in which occur several thin seams of impure dolomitic limestone. The sandstones are succeeded upwards by a group of thin-bedded dolomitic limestones, and dark grey shales, the "cement limestones" of the survey. These are well exposed in the railway cutting near Prince's Pier Station, Greenock, and, in the same district, in the hills around Loch Thom. They are of the same age as the group of thin-bedded limestones which is seen, at the Spout of Ballagan and at other points, underlying the traps of the Campsie and Kilpatrick ranges of hills north of the Clyde. It was pointed out that the trap rock forming the range of hills of Renfrewshire and North Ayrshire, and which here border the Gourock shore, lay over this group of limestones and lower red sandstones, and is intermediate in position between the Ballagan limestones and those marine limestones which lie at the base of the Carboniferous limestone series proper—being thus of calciferous sandstone age.

It was next remarked that the Valley of the Clyde is a valley of denudation, being scooped out of the red sandstone strata formerly mentioned, and that probably its origin as a valley dates far back into pre-glacial times, although it may subsequently have been widened and deepened along its course, at several points, by the grinding action of the ice of the glacial period, and previous to the laying down of the boulder till and other Post-tertiary deposits, by which it has again been partially filled. In the ramble along the coast several large boulders of schistose rock were noticed on the

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beach. These, as also some granite boulders of smaller size, have evidently been brought by ice from the Argyllshire mountains, on the opposite side of the Firth.

The party were then conducted to the large whinstone quarry on the hill-side at Kempock Point, where a fine section of trap, nearly 100 feet in height, is exposed. This rock is a fine-grained felstone porphyry, having a rudely columnar structure, and of a pale greenish-brown colour. In former years, when it was quarried nearer to the face of the hill than now, circular cavities, termed "druses," were now and again met with in it, and these were lined with crystals of quartz, calcite, dolomite, and fluor-spar of a deep purple colour, this being the only recorded locality, in the West of Scotland, for the latter mineral. A search was made by the party for these "druses," with their crystals, but only two small examples containing fluor-spar were found, the rock being more compact than formerly. It was intended to have visited the old copper-mine quarry, but, daylight failing, the way was taken to the Gamble Institute, where tea was provided. After doing full honour to the good things, and passing a vote of thanks to Mr. Wilson, for his kindness in conducting the excursion, the party returned by train to Glasgow.

Y.

BATHGATE.

9th June, 1877.

The closing excursion of Glasgow for the season was to the district of Bathgate, in Linlithgowshire. Mr. James Thomson, F.G.S., was the conductor for the day, and the weather was most favourable.

Leaving College Station by the 10.35 a.m. train, the party were soon speeding along through a most interesting country, including the parishes of New and Old Monklands, with their chief towns, Coatbridge (the Dudley of the Scotch "Black Country,") and Airdrie. Within a very limited area there were seen the famous Gartsherrie Iron-works of Messrs. William Baird & Co., where there were no fewer than twelve open-topped blast furnaces in full operation; the Summerlee Iron-works, with six furnaces in blast, mostly close-topped; Langloan Iron-works, with seven furnaces in operation; Calder Iron-works (William Dixon & Co., Limited), with five furnaces at work; and Carnbroe Iron-works (Merry & Cuninghame), with six blast furnaces in operation. There was also seen the classic ground on the banks of the Calder, where David Mushet, in the beginning of the present century, discovered the famous Blackband ironstone, the working of which has since proved to be such a mine of wealth to the "iron lords" of Scotland. A few miles to the south-east there were the Shotts Iron-works, one of the oldest establishments of the kind in Scotland, dating from the year 1802. After proceeding eastwards for a few miles further, the party came into a totally different district as respects its geological features and its mineral deposits. Practically entrance was obtained to it at

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Armadale station, where the Scottish oil region may be said to begin; and in a few minutes the veritable Boghead pits of James Russel & Son, where the famous Torbanehill Mineral was worked, were seen and passed close by the railway line. Immediately a perfect forest of chimneys indicated the proximity of the Bathgate Chemical Works, which Mr. James Young, F.R.S., and his partners, Mr. Edward Meldrum and Mr. E. W. Binney, F.G.S., of Manchester, set agoing fully a quarter of a century ago for the distillation of oil and paraffin, and which soon became one of the most remarkable seats of industrial chemistry in the world.

Without waiting to devote any time to the oil manufacture or other industries of Bathgate, the excursionists at once made their way, under the guidance of their conductor, to Petershill limestone quarries, which are at a considerable elevation on the north-east side of the town. In these quarries, the rock-face of which is from 60 to 70 feet in thickness, the lower members of the Carboniferous limestone were seen beautifully exposed, and at the base of the section a bed of calcareous shale, containing *Pecten fimbriatus* in an excellent state of preservation. As the shale had recently been dug through, in the course of construction of a large reservoir for a new water-supply for Bathgate, many specimens were procured. Many varieties of polyzoa and other delicate organisms were likewise found in a finely-preserved condition, as also two very fine specimens of fish teeth. The party passed eastwards along the face of the old quarries, where some beautiful examples of Carboniferous corals were got, including large masses of compound corals belonging to the genera *Cyathophyllum*, *Lonsdaleia*, *Diphyphyllum*, *Lithostrotion*, and *Koninckophyllum*, more especially the rare and beautiful species of *proliferum*, not yet discovered elsewhere in Great Britain. Here Mr. Thomson directed attention to a fine section of glacial drift, which was seen to fill up a fault or pocket in the limestone, and containing erratic boulders transported by ice from great distances—porphyries from the West Highlands, as also diorites, dolerites, &c.

A little further along the party came upon a portion of the rock-face where quarrying operations were actually in progress, and where the limestones were admirably developed in the bedded condition. Several rare and interesting fossils were obtained, including specimens of *Euomphalus*, *Bellerophon*, and very large examples of *Axinus* and of *Productus*. They then ascended several hundred feet higher to the old quarries on Knock hill, which were worked on a most extensive scale upwards of a hundred years ago. At this section an excellent view was obtained of the stratified shales which overlie the lowest part of the limestones, and in which there were seen interstratified thin bands of sandstone containing evidences of the burrowing operations of innumerable annelids, and of ripple-marks of the receding tide. At a still higher elevation the encrinital limestone was seen well exposed, and in it there were found a number of the dome-shaped masses of compound corals which characterise the same horizon of strata throughout the British Isles; and also specimens of those very delicate compound corals, *Alveolites capillaris* and *A. depressa*, in a beautiful state of preservation. At this point Mr. Thomson described

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the section, and explained its relation to the other deposits of Carboniferous limestone throughout Scotland. He also noticed the principal organic remains, and specially dwelt on the stratigraphical aspect of the deposit.

The party next passed to the crown of the hill, where the igneous rocks had been ejected through the stratified rocks, altering alike their stratigraphical aspect and their mineral character, and where a magnificent panoramic view was obtained of the surrounding country. The Ochil, Lomond, and Pentland hills were seen, the Firth of Forth, Arthur's Seat, and other surroundings of the Scotch metropolis, and portions of at least seven counties, including Fife and Clackmannan, Midlothian, Peebles, Linlithgow, Lanark, and Stirling. After the party had for a brief space of time contemplated the glorious expanse of country—hill and dale and strath—Mr. Thomson gave a brief and very graphic description of the geological phenomena illustrated by the region within view. In the first place he referred to the great dislocations which had been produced in the strata throughout the district. He then pointed out where the oil shales and other members of the Carboniferous strata of the district terminated, and where the equivalents of the well-known Burdiehouse limestones had been thrown up by igneous agency, as in the case of Binney Hill, which was a prominent feature in the landscape; and he also pointed out certain spots where those beds had been deposited in cup-shaped basins, incidentally naming many members of the fauna and flora found in the same horizon of strata, and dwelling at some length upon the fossil remains of the ganoid fishes discovered and described by the late Dr. Hibbert, more especially *Rhizodus Hibberti* and *Megalichthys Hibberti*. Notice was also taken of the trough-shaped basin in the valley of the Forth, and of the stratified rocks occurring along the shores of the Forth, on both sides, where the mountain limestone is exposed, and where on the north side it passes inland to near Kinross, and is overlain by well-exposed red sandstones, which some geologists suppose to be of Permian age. Mr. Thomson likewise remarked upon the geological features of the southern shore of the Firth, and of the Carse of Stirling, and then drew attention to the great dislocations of strata which might be observed, more especially the great fault near Castlecary, where the upper Carboniferous limestones were seen exposed in juxtaposition to the highest members of the upper coal measures, a distance which, in the normal condition of things, ranges in Scotland from 300 to 400 fathoms. Directing his attention to the south and east of Bathgate, he described the stratified deposits as far east as the Pentland Hills, where the relation of the Silurian and the Old Red Sandstone strata to the Carboniferous deposits of the valley was passed under review. In this connection it was impossible to avoid referring to the famous Torbanehill mineral or Boghead coal, which had given such celebrity to the neighbourhood, but now almost entirely wrought out, only very small patches being found here and there. The curious fact was mentioned that it invariably occurred in small basins, and that the parrot or gas coal was seen to pass by imperceptible gradations into blackband ironstone, which sometimes attains a thickness of 10 inches, and which is the equivalent of the Govan and Possil blackband ironstone in

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the Glasgow district. Extending his view a little further south, Mr. Thomson spoke of the slatyband ironstone, which occurs in the neighbourhood of Crofthead and in other mining localities along the northern boundary of Lanarkshire: and in passing he spoke of the Levenseat limestone shales, which, while they were used for oil-making, were the geological equivalents of the Castlecary limestone. In conclusion, he remarked that the mining operations in the Bathgate district had been rendered very difficult, in consequence of the frequency of dislocations produced in the Carboniferous strata by igneous action.

At the close of his interesting address Mr. Thomson was awarded a very hearty vote of thanks. The party then returned to Bathgate, where they sat down to an enjoyable dinner in the Royal Hotel, and in the evening returned to the city of Sanct Mungo, greatly delighted with the day's excursion, and with what they had seen and heard.

J. M.

MIDCALDER.

18th May, 1878.

Joint Excursion with the Edinburgh Geological Society.

Saturday, the 18th May, had been fixed upon by the Geological Societies of Edinburgh and Glasgow for a joint excursion, and the field chosen being Midcalder and district, the former Society acted as hosts, the latter as guests. The morning ushered in as stormy and wet a day as could be, but about noon the clouds racked, the rain ceased, and the afternoon proved all that could be wished, although the roads bore traces of the recent downfall.

Between 30 and 40 members of the Glasgow Society left Buchanan Street station, some at 12 and some at 2 p.m., and were met at Midcalder station by nearly as many representatives of the Edinburgh Society, the party being under the leadership of Mr. James Melvin, of Bonnington, one of the Vice-Presidents of the Edinburgh Society. The Glasgow Geologists were highly pleased to meet with a number of the best workers in the east, who have been steadily and enthusiastically working out the geology and palæontology of the interesting districts around Edinburgh, the results being year by year recorded in the *Transactions* of the Edinburgh Geological Society.

Amongst others may be mentioned the veteran naturalist and geologist, Mr. C. W. Peach, A.L.S., hale and hearty in spite of his years, and to whom natural science is indebted for many interesting discoveries, and Mr. James Bennie, late of Glasgow, the able and industrious collector to the Geological Survey of Scotland, and to whom we owe many palæontological discoveries of interest. There were also present Mr. William Ferguson of Kinmundy, Aberdeenshire, F.L.S., F.G.S., one of the founders of the Natural History Society of Glasgow, of which he is still an honorary member, and senior Vice-President of the Edinburgh Geological Society.

The party first proceeded to the quarries of Raw Camps. The section of limestone worked in them belongs to the well-known Burdiehouse series, a

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group which lies in the upper division of the calciferous sandstone formation, which here, as in other districts of Scotland, forms the lowest division of the Carboniferous system. So far as palæontological evidence goes, the Burdiehouse limestone and its immediately associated strata appear to be of lacustrine origin, with evidences at one or two stages of old land surfaces, clearly indicated by their seams of coal, in which are found the erect stumps of large fossil trees, belonging either to a species of *Sigillaria* or of *Lepidodendron*, and which are further proved to have grown on the spots where they are now found, from the occurrence in the underlying stratum of the roots of *Stigmaria ficoides* with root-leaves attached. The other fossil remains found in this group consist of various species of plant remains, amongst which the beautiful fern *Sphenopteris affinis* is especially abundant. *Microconchus (Spirorbis) carbonarius*, a small annelid, is also common, and is believed to have attached itself to the plant remains which were drifted into the lake deposits then in course of formation. The Entomostraca, a small genus of bivalve crustaceans, are here represented by one or two freshwater forms, one species being specially abundant in this horizon of strata, viz., *Leperditia Okeni*, variety *Scoto-burdigalensis*, which in some layers is so numerous as to have contributed largely to the building up of the deposit.

At the base of the Burdiehouse limestone at these quarries, and in one or two other places, there has recently been discovered a thin stratum of limestone, known to the quarrymen and miners as the "Buckie-fake" band. It is largely composed of a small gasteropod shell, recently figured and described by Mr. Robert Etheridge, jun., palæontologist to the Geological Survey of Scotland, under the name of *Littorina Scoto-burdigalensis*. As the foreman of the quarry had laid out slabs, the members of the party who were collecting were enabled to secure fine specimens of this interesting fossil.

As already stated, the fossils of the Burdiehouse limestone indicate lacustrine conditions of formation, so this little shell is more likely to be allied to the freshwater Paludinidæ, than to the Littorinidæ, which are more essentially marine in their habitat, and with which it is now provisionally placed. If this view should be confirmed by further observations, as suggested by Mr. Etheridge, then the Paludinidæ will have been carried back to a date much earlier than that previously assigned for them, the genus not being known hitherto in rocks older than the Wealden strata.

The only other organisms found in the present series are the remains of fishes chiefly belonging to the Ganoid family, the largest being *Rhizodus Hibberti* and *Megalichthys Hibberti*. These fishes seemed to have preyed largely upon the smaller genera of fish—these in their turn feeding upon the entomostraca, while these last lived upon the decaying plant remains of the lake deposits—a fact which was long ago pointed out by Mr. Charles M'Laren, in his "Geology of Fife and the Lothians."

The Burdiehouse limestone group is succeeded in descending order by strata of sandstone and shale with thin-bedded limestones, in which have been found, at intervals, beds, containing marine organisms, although the

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calciferous sandstone group as a whole has been generally viewed as essentially of lacustrine or estuarine origin. In ascending order, again, the Burdiehouse beds are overlaid by strata belonging to the lower Carboniferous limestone group, which are truly marine, and abound in the remains of corals, crinoids, polyzoa, and mollusca. Yet in this group strata are not awanting to indicate the existence of old land surfaces and freshwater deposits over certain tracts of country—a feature characteristic of the Carboniferous limestone group of Scotland compared with that of other countries.

The limestone strata were here seen no less than 42 feet in thickness, and in many places dipping at a high angle, sometimes in one direction, sometimes in another. This feature is due, as was pointed out, to a series of faults and flexures of the strata in the basin in which they now lie; and the letting down which caused these appearances was in all likelihood the means whereby this tract of limestone was preserved from denudation; for it is clearly evident, from the lithological characters of the Burdiehouse series in the several basins and patches where it now occurs, that it once formed a continuous group of deposits, though now so separated and isolated by great surface denudation. A very instructive example of faulting was pointed out by Mr. Melvin in one of the quarries. Here the limestone had been let down in the form of a V-shaped angle, with the sides at about 30 degrees of inclination. At the lowest point the limestone had been crushed and folded partly upon itself by lateral pressure, the rock being traversed in many directions by veins of calcite, while its whole surface in the lines of these fissures, as well as in the overlying shales, had been most beautifully smoothed by slicken-sided markings.

After an examination of this most interesting section, which was rendered more than usually accessible through the large extent of surface laid bare for quarrying purposes, the party proceeded to the Camps Quarry, or, as it is locally called, we believe, Burnside Quarry. Here, through the kindness of Mr. Torrance, the lessee, an opportunity was given of inspecting one of Messrs. Chaplin's steam diggers at work in "tirring" the overlying clay from the surface of the rock. It may be remarked that all the workings visited up to this point were upon the open-cast principle, but from the high angles at which the rock often lies, no great extent can be followed in any one place before the depth of overlying shale and surface deposits is so great that the expense of removing them becomes excessive. To lessen this the digger has been put in operation, and Mr. Torrance explained that it performs its work equally well either in the clay or in the soft Carboniferous shales. The limestone has here also been largely worked in the line of dip, in underground chambers of great height on the "stoop and room" principle, the rock being drawn to the surface in hutches, up long and highly-inclined rails, by a stationary engine placed on the quarry hill. Down the inclines scrambled and slid the members of the party, some of them assuming the recumbent position when a loose stone or the slippery shale gave way beneath their feet. On reaching the bottom, under the vast mass of superincumbent rock and shale, the miners could be seen standing with blazing paraffin lamps in

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their hands, ready to conduct the party to the farther end of the workings, and, accordingly, on they pushed along the line of rails laid down for the hutches, almost on a level, the limestone shortly after the entrance losing its dip and taking a nearly horizontal direction. Mr. Richardson, the Secretary of the Edinburgh Society, had brought several Bengal lights, and these having been set fire to at intervals, lit up the gloomy caverns with weird and curious splendour, like the caves of Eblis in the pantomime. A good suggestion was made by some one, that if the lime-light had been arranged for, a photograph of the party might have been taken, which would have commemorated the excursion at its most remarkable point. The only quarries in the Glasgow district which have the least resemblance to these remarkable workings are those of the Giffnock sandstone quarries, near Pollokshaws, where a stratum of white Carboniferous sandstone, from 30 to 40 feet in thickness is being worked on the same principle, and on a great scale.

After minutely inspecting the workings, the party regained the light of upper day, and set out for Ratho. Before doing so, a hearty vote of thanks was asked, by Mr. Peach, to be given to Mr. Torrance, for his kindness in having the workings laid open for inspection, and the men at hand to guide the party, which was cordially responded to by the members. After a walk of about two miles the party reached Bonnington Mains, the house of Mr. Melvin, their conductor, who had made open house on the occasion.

After ample justice had been done to their host's generous hospitality,

Mr. Richardson, Secretary of the Edinburgh Geological Society, proposed "Success to the Geological Society of Glasgow." He said that a number of years ago the Edinburgh Society had paid a visit to Strathblane and the Spout of Ballagan on the invitation of their Glasgow friends, and though not then connected with the Society, he knew that pleasant memories of the trip still remained with all those who had been privileged to be present. It was now their turn to invite their Glasgow friends, and he hoped that such interchanges of good-fellowship and kindly feeling would long continue between members of the two Societies.

Mr. Murdoch, Secretary of the Glasgow Society, then responded. He entirely, on the part of his Society, reciprocated the feelings which had been expressed by Mr. Richardson, and hoped that, together, the two Societies would be enabled to work out satisfactorily the geology of the Scottish Midlands, a work which so far they had satisfactorily proceeded with. He thanked the members of the Edinburgh Society for putting before their notice such noble and instructive sections as had been shown them this day.

Mr. John Young, F.G.S., Vice-President of the Glasgow Society, next gave a short account of the strata over which they had passed, comparing them with the western beds. He proposed success to the Edinburgh Geological Society, and health and prosperity to Mr. Melvin, Vice-President, and their guide and host for the day. Mr. Melvin, in reply, said it gave him exceeding pleasure to see his friends from the West, to entertain them, so far as he could, in a geological way, and to offer them a farmer's hospitality.

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Mr. Wm. Ferguson, of Kinmundy, F.L.S., F.G.S., senior V.P. of the Edinburgh Society, also responded briefly.

From Bonnington to Ratho Station Mr. Melvin kindly accompanied the excursionists, and pointed out, along the route, the extent of country covered by the doleritic trap, and the occurrence of glacial striæ over its surface, well exposed at some of the quarries, which time, however, did not permit the party to visit. Not far from the station, where the trap comes to the surface, specimens were obtained by those interested in the study of volcanic rocks. As the train for Glasgow came in sight, the brethren of the West bid good-bye to their friends of the East, thanking them heartily for the pleasant and instructive hours which they had passed together, hoping that in an early season the two Societies might be able to arrange another meeting, and then amidst some of the geological scenery of Western Scotland. As the carriage doors were shut, a hearty cheer rang around, and the Glasgow men beguiled their homeward journey by recounting the incidents of the day, reaching Glasgow about 10 p.m., a weary but happy party.

Y. and M.

CRAIGNETHAN GLEN AND TILLIETUDLEM.

Queen's Birthday Excursion, 24th May, 1878.

The locality chosen for this year's excursion was Tillietudlem Castle and Craignethan Glen, not less worthy of notice from their historical than from their physical features. As on some previous occasions, the Natural History Society of Glasgow made their outing to the same spot as their friends of the hammer, many gentlemen being members of both Societies. The morning of the day opened lowering and wet, and it seemed as if the clerk of the weather had set his face against outdoor enjoyment. However, the event proved otherwise, and from the time of leaving the South-side station at 11.15 a.m. till their return at 8.30 p.m. hardly a drop fell on the excursionists, although late in the afternoon Glasgow was visited with a deluging rain. On arriving at Tillietudlem station the party was met by Dr. J. R. S. Hunter, of Daleville, Braidwood, Carluke, one of the Society's corresponding members, who had kindly agreed to take charge of the excursion and act as conductor to the points of interest in the neighbourhood. There were also on the platform to welcome the party, Dr. Robert Slimon, of Lesmahagow, so well known amongst geologists for his researches and interesting discovery of large crustacean remains in the Upper Silurian rocks of the district; and Mr. William Templeton, of Nethanfoot, Crossford, an early worker in the geology of this neighbourhood.

Ten minutes walk brought the party to the Castle, and after a short inspection of the ruins a gathering was made on the slope between the exterior walls and the river, a spot sweetly shaded with trees, and from which could be seen the Nethan rippling far below. Here Dr. Hunter, standing amongst his friends, gave an account of the famous old Castle and

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its possessors, passing on to the salient geological features of the Glen and district, which he briefly but clearly sketched. (See page 96.)

On the conclusion of Dr. Hunter's interesting and valuable paper, a cordial vote of thanks was awarded to him by acclamation. The party now proceeded from labour to refreshment, and a pleasant hour was spent in reinvigorating the inner man. Quite unexpectedly, Dr. Hunter had brought on the ground baskets filled with good things, and to these due attention was paid. A call was next made for the party to assemble near the south-west corner, where a photograph was taken by Mr. Thomas Annan, of Sauchiehall Street, one of the Society's members.

Dr. Slimon then gave a short sketch of the district lying nearer Lesmahagow, and from which he had disentombed the celebrated *Pterygotus*, *Slimonia*, and other gigantic crustaceans, previously unknown to science. Mr. John Young, F.G.S., Vice-President, also made some remarks upon the geology of the district. The gathering then broke up so that individual members might follow for a time the bent of their own fancy—some to explore the natural beauties of the glen, others, under the guidance of Dr. Hunter, to examine its geological features, whilst a few remained to make a more careful study of the Castle ruins.

At the edge of the terrace outside the south-east corner of the Castle walls were noticed three magnificent old yew trees, evidently of great age. A measurement of the central one was taken, and at three feet from the ground it proved to have a girth of ten feet. The Botanists also noticed a number of rare plants, amongst which may be mentioned—*Anchusa sempervirens*, the evergreen Alkanet; *Arum maculatum*, Cuckoo-pint, known in England as "Lords and Ladies;" *Scrophularia Ehrharti*, Ehrhart's figwort; and *Chelidonium majus*, a plant which probably has been introduced, but is now plentiful enough.

At six o'clock the party began to reassemble, and a few complimentary speeches were made on the rising ground above the Castle. At seven o'clock the train left for Glasgow, which was reached in due course, the excursionists agreeing that they had never spent a more enjoyable holiday.

M.

DALRY.

8th June, 1878.

The last excursion of the Society for the season was to Cunningham Baidland on the Rye water, a glen which lies upon the hillside two miles north-west of the town of Dalry, in which interesting sections of the Carboniferous limestone series are exposed, and from which many species of limestone fossils have been obtained during recent years. The party left Glasgow by the 1.30 p.m. train, and as the day did not threaten to become so wet as it afterwards proved to be there was a good turn out, including a number of the more prominent members of the Society. At Beith station the party was joined by Mr. Robert Craig, of Langside,

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Beith, corresponding member, a gentleman who has done much by his valuable papers, many printed in the *Transactions* of the Society, to elucidate the geology of this interesting district. Mr. Craig had kindly consented to conduct the party, and on arriving at Cunningham Baidland glen he explained the position and relation of the strata to those which occur in the other portions of the Ayrshire coal-field.

The beds of the Dalry basin, he stated, lie in the Carboniferous limestone group, and consist of an upper and lower series of limestones, which are separated from each other by a considerable thickness of strata, in which lie the several seams of coal, and blackband and clayband ironstones, so long worked in this district for iron-producing purposes, this group being the equivalent and in the same geological position as that of the Possil and Govan coals and ironstones around Glasgow. In the Dalry district the upper limestone series of beds is known as the Highfield and Linn Spout limestones, from being well exposed at these places. The lower limestone series is that so extensively worked in the large open-cast quarries around Beith and Dalry, for iron-smelting, as well as for building and agricultural purposes. Both these groups of limestone are here found in greater thickness than the limestones of the same geological position in any of the other districts of Western Scotland. They lie upon a great group of bedded traps, which come to the surface at many points over the district, and which to the north form the long-extended range of hills, running from near Ardrossan eastwards into Renfrewshire, these traps being of calciferous sandstone age, and belonging to the lower Carboniferous period.

Mr. Craig pointed out that in the middle coal and ironstone groups which lie between the two limestones there is evidence in the Dalry basin of a considerable amount of volcanic action, in the form of contemporaneous showers of volcanic ash, forming conical bosses and extended sheets within the basin, and cutting off the coal and ironstone at several points. He also pointed out, in ascending Cunningham Baidland glen, how, by a series of faults, the strata had been brought to the surface, to the north, or thrown down into the Dalry basin, to the south, according as these faults may be viewed. At the quarry on the hillside in the lower limestone series some instructive examples of fissures were observed, which by former horizontal movements of the crust in an east and west direction had had their faces rubbed against each other, and now show those polishings, groovings, and striations which are known as slicken-sides, and which have been produced by both vertical and horizontal movements in the strata. In the lines of these fissures the limestone is much eroded by the passage from the surface of rain-water charged with carbonic acid, which has eaten or dissolved away the limestone, leaving only a reddish-brown non-calcareous earth. In this are found such shells, corals, and crinoids as have had their structure silicified during fossilization.

A great interest is now attached to the brown earth found filling these fissures in the limestone at Cunningham Baidland, as here, for the first time in the history of geological discovery, have been found in great abundance the remains of fossil Carboniferous sponges, which had not for-

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merly been recorded from this formation. The discovery was made in 1876, and is due to the ability and discrimination of Mr. John Smith, of the Eglinton Iron-works, one of the members of the Society, who in that year submitted a series of specimens from this deposit to Mr. John Young for determination. These, on examination, turned out to be the remains of a silicious sponge, closely allied to the recent glass sponge—*Hyalonema Siebaldii*—found in the seas of Japan. The specimens found at Cunningham Baidland consisted of the long slender spicules forming the rope or stem, and the beautiful star-like spicules which existed in the body of the sponge. These fossil remains have been described by Professor Young and Mr. John Young, and named *Hyalonema Smithii*, after their discoverer. The remains of other forms of sponges have been found in the rotted limestone—one with a reticulated structure being named by Dr. Young and Mr. Young *Haplistion Armstrongi*, after its discoverer, Mr. James Armstrong.

The work of exploration at this quarry consisted in searching the eroded fissures for the brown earth containing the sponge spicules and other organisms. After a sufficient supply of the material had been obtained, the party returned to the station at Dalry, whence, giving a hearty vote of thanks to Mr. Craig for his able conductorship, they proceeded by the first train to Glasgow.

Y.

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Abstract of the Treasurer's Accounts for Year ending 30th September, 1876.

REVENUE.

RECEIPTS.							DISBURSEMENTS.						
Balance due by the Treasurer at close of last Account,	£3	4	8				Printing *Transactions*,				£60	5	0
Do. by Librarian at do.,	1	4	11	£4	9	7	Rent, Gas, Taxes, Insurance, and Attendance,				15	11	2
Subscriptions—Arrears for 1873-74,	£0	10	0				Printing Circulars and Receipt Book,				0	17	9
Do. for 1874-75, 20 at 10s.,	10	0	0				Collector's Commission, Postages, and Petty Charges,				5	15	6
Subscriptions for current year, 163 at 10s.,	81	10	0				Disbursements by Secretary,				7	3	4
New Members, 18 at 10s.,	9	0	0	101	0	0	Do. by Librarian,				1	11	6
Life Subscription (T. D. Smellie).				5	5	0	Lodged in Bank,				217	16	10
Publications sold,				1	5	9	Balances—Due by Treasurer,	£0	19	11			
Petty Receipts,				5	17	4	Do. by Librarian,	0	19	2	1	19	1
Drawn from Bank,				193	2	6							
				£311	0	2					£311	0	2

STOCK.

Life Subscription Account,				£89	5	0	Cash in Bank on Deposit Receipt,				£85	19	1
Sundry Liabilities,				61	0	6	Do. on Current Account,				33	2	10
Balance to Credit,				145	15	6					£119	1	11
							Cash in Treasurer's hands,	£0	19	11			
							Do. in Librarian's hands,	0	19	2			
											1	19	1
							Publications, Fossils, and Casts,				175	0	0
				£296	1	0					£296	1	0

GLASGOW, 10*th October*, 1876.—We have examined the foregoing Accounts, and compared the same with the Vouchers, and find them correctly stated and sufficiently vouched, the balance in Treasurer's hand at 30th September being Nineteen Shillings and Eleven Pence sterling.

(Signed) WM. BAXTER, C. P. HOGG, } *Auditors.*

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Abstract of the Treasurer's Accounts for Year ending 29th September, 1877.

REVENUE.

RECEIPTS.

Balance due by the Treasurer at close of last Account,	£0	19	11			
Do. by Librarian at do.,	0	19	2	£1	19	1
Subscriptions—						
Arrears for 1875-76, 8 at 10s.,	4	0	0			
Subscriptions for current year, 175 at 10s.,	87	10	0			
New Members, 17 at 10s.,	8	10	0	100	0	0
Life Subscriptions, 2 at £5 5s.,				10	10	0
Publications sold,				11	10	0
Interest on Cash in Bank,				1	16	10
Drawn from Bank,				116	16	7
				£242	12	6

DISBURSEMENTS.

Printing Dr. Geikie's Paper and Map,				£32	17	6
Rent, Gas, Insurance, and Attendance,				13	5	7
Printing Cards, Circulars, &c., and Stationery,				35	3	6
Engraving,				1	7	0
Subn. to Palæontographical Socy. for 3 years (1875-6-7),				3	3	0
Reporting Sir Wm. Thomson's Address,				2	2	0
Collector's Commission, Postages, and Petty Charges,				4	15	6
Disbursements by Secretary,				6	18	2
Do. by Librarian,				1	19	3
Lodged in Bank,				139	18	5
Balances—Due by Treasurer,	£0	12	8			
Due by Librarian,	0	9	11	1	2	7
				£242	12	6

STOCK.

Life Subscription Account,	£99	15	0
Sundry Liabilities,	40	17	0
Balance to Credit,	177	14	4
	£318	6	4

Cash in Bank on Deposit Receipt,				£129	15	4
Do. on Account Current,				12	8	5
				£142	3	9
Cash in Treasurer's hands,	£0	12	8			
Do. in Librarian's hands,	0	9	11	1	2	7
Publications, Fossils, and Casts,				175	0	0
				£318	6	4

GLASGOW, *22nd October*, 1877.—We have examined the foregoing Account, and compared the same with the Vouchers, and find it correctly stated and sufficiently vouched, the Balance in Treasurer's hand at 30th September last being Twelve Shillings and Eight Pence sterling.

(Signed) SIG. SCHUMAN, JOSEPH SOMERVILLE, } *Auditors.*

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TRANSACTIONS

OF THE

GEOLOGICAL SOCIETY OF GLASGOW.

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TRANSACTIONS

OF THE

GEOLOGICAL SOCIETY

OF GLASGOW.

VOL. VI.—PART II.

1878-79, 1879-80.

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The Editor begs to state that the Authors are alone responsible for the facts and opinions contained in their respective papers.

R. Anderson, Printer 22 Ann Street, Glasgow.

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TRANSACTIONS

OF THE

GEOLOGICAL SOCIETY OF GLASGOW.

XIX.—Notes *on the* Geology *of* Colonsay *and* Oronsay. By James Geikie, LL.D., F.R.S., F.R.S.E., &c., of H.M. Geological Survey. With a Map [Plate V.].

[Read 10th October, 1878.]

The islands of Colonsay and Oronsay have been described by Macculloch as "extremely uninteresting in a geological view, and might, but for their topographical claims, have passed unnoticed." And this is true if regard be had simply to the petrology of the principal rock masses, for, as Macculloch tells us, "the predominant rock of these islands is micaceous schist." There are, however, some interesting varieties of rock, not mentioned in his short description, which are worthy of notice, not to mention the glacial phenomena of the islands—which, of course, in Macculloch's time were almost entirely disregarded.

Physical Features.—Having recently had an opportunity of examining the geology of these islands, I purpose bringing before the notice of this Society the results of my observations. Colonsay, the larger of the two islands, measures some 9 miles in length by about 3 or so in breadth. Like so many of the Hebrides, it extends in a north-east and south-west direction, and is separated from Oronsay by a narrow and shallow channel, which at low-water may be crossed on foot. Oronsay, which contains about two square miles, may, in fact, be considered as merely the southern prolongation of Colonsay. As we approach it from the east Colonsay has a barren, uninviting appearance, the shores being rocky and often precipitous, and the prospect inland being closed by bare, rugged hills. But the interior is extremely fertile, showing wide stretches of pasture-land and good agricultural farms. The

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luxuriance of the trees in the neighbourhood of Colonsay House astonishes the stranger, who, while wandering in their glades, might easily fancy himself in some well-wooded part of the Lowlands. Here we find growing vigorously in the open air all the year round several plants which on the mainland could not survive the winter. Much of the fertility of the districts bordering on the sea is derived from the shelly sand which the Atlantic supplies more or less abundantly to all the islands of the Inner and Outer Hebrides. This sand supports a beautifully green turf, which in summer time is gay with wild flowers, affording colour-effects for which the landscape-painter may search the pasture-lands of the mainland in vain. The greater portion of Oronsay is of this character.

The hills are, as a rule, rugged and bare, but never present the extremely barren aspect of the hills of Harris and other islands of the Outer Hebrides, which are often quite destitute of soil and verdure of any kind. On the contrary, grass and heath find soil and shelter almost everywhere upon the gentler slopes and in the hollows of the hills. These hills, however, are broken and rough, showing innumerable tors of bare rock, and considerable slopes and crags, on which nothing grows.

Silurian Strata.—The geological structure of the islands is very simple. They are composed, as Scottish geologists are well aware, of rocks belonging to the great Silurian system, more or less altered or metamorphosed. The strike is approximately north-east and south-west, and the prevalent dip is to the south-east. Occasionally the dip is in the opposite direction; and one can hardly doubt that, even in those districts where the dip is continuous, there are many foldings and doublings of the strata, causing the same beds to crop up again and again. In Colonsay the beds generally dip at a high angle, but in Oronsay the dip is low and in various directions.

The strata consist principally of grits, mica-schist, gneissose rocks, slatey and flaggy shales, &c. The grits are hard, close-grained, and sometimes coarsely granular rocks, arranged in beds that vary in thickness from a few inches to several feet or yards. Their prevailing colour is grey and greyish-blue. They are, for the most part, much jointed, fissured, and broken. In some places, as on the sea-shore near Kilchattan, they occur in more massive beds than usual, and are not more altered than much of the greywacké or grit of the Lammermuirs and other Silurian regions in the south of

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Scotland. Along with these grits we usually get intercalated bands and beds of altered shales, which, in the more highly metamorphosed areas, pass into micaceous schists. In such areas the grits themselves shade off into rudely granular quartz rocks.

Now and again the micaceous schists show a very considerable thickness, with intercalated beds of grit. They are often crumpled and much twisted, but are seldom so highly metamorphosed as some of the schists of the Highlands. Occasionally we find them associated with gneissose rocks, which, however, seldom attain the distinctly crystalline texture of the more typical gneiss of the Outer Hebrides and Northern Highlands.

Such is the general character of the strata that form by much the larger portion of Colonsay and Oronsay. Along the east coast of the islands, however, and occupying therefore a higher place in the series, occur grey and blue flags, and slatey and flaggy shales, which show much less alteration, and approach closely in character to similar strata in the Silurian uplands of Southern Scotland. The beds referred to are well exposed upon the shore between Lochsturrsneg and Eilean Martin, and in quarries at Baleroman Dubh, and on the side of the road a little south of Maol Buidhe. None of the shales are true slates, although they sometimes simulate these in general appearance. They are often soft and friable, and show waved and crumpled laminae. The flags, however, with which they are associated are generally even in the bedding. Here and there they show ripple-marks, but I found no trace of any fossils. Similar shales and flags occur on the sea coast, a mile or two south of the point called Rudha Geodha, and comparatively unaltered greywacké and shale appear also in the island of Gartmeal.

Associated with the flaggy shale of Baleroman Dubh we find an irregular bed of calmy or argillaceous limestone. It is of very variable thickness, and passes into calcareous greywacké. Where I saw it exposed it did not exceed six or seven feet, and much of that was rather calcareous greywacké than limestone. It yielded no fossils.

These small areas of comparatively unaltered rock indicate pretty clearly what was the general character of the strata before extreme metamorphism ensued. They evidently consisted of a series of blue argillaceous shales and argillaceous and siliceous sandstones and flags.

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Both greywackés and shales are often rudely cleaved, but the cleavage never, so far as I saw, obscures the bedding. Indeed, throughout the whole of both islands the stratification, despite metamorphism and contortion, is remarkably distinct.

Crystalline Granitoid Rock.—In the neighbourhood of Schallasaig there occurs a mass of a coarsely crystalline rock of a very hard, tough, and durable character. It consists of a milky felspar, probably labradorite, which sometimes shows a rosy flush, with a tough, dark green, almost black, mica, not unlike lepidomelane, and minute quantities of a pyroxene. It forms a handsomely-marked rock—the pale and dark-coloured minerals being in about equal proportions—and might be advantageously employed as an ornamental building stone. It is excessively tough, and not easily affected by weathering—differing in this respect from many of the granitoid rocks which are wrought in Scotland. For structures requiring great strength and durability, hardly a better stone could be desired, as its crushing power must be very considerable. It is locally known as the "Colonsay granite;" but, of course, it is not a true granite.

Syenite.—Another crystalline massive rock, which appears to be of igneous origin, is a syenite consisting of pink felspar and dark green hornblende. It occurs near Port Skipness, in the north of Colonsay—in which district the schistose and gneissose strata are much broken and confused.

Volcanic Agglomerate.—Near the same place occurs a remarkable volcanic agglomerate. It is well seen upon the shores of the little indentation in Killoran Bay called Port Easdale. This rock is made up of the broken angular *débris* of the strata by which it is surrounded. It precisely resembles the volcanic "necks" which occur so plentifully in Ayrshire, Fifeshire, and other parts of the mainland, and has evidently had a similar origin. The pipe or neck apparently cuts the strata in a vertical direction, and must certainly belong to a very much later date. It is possibly of the same age as some of the igneous rocks of Mull. The rocks surrounding it are much broken and confused, and a dyke of basalt traverses these and the agglomerate alike.

Basalt Dykes.—Dykes of basalt are met with in several other places, as near Schallasaig and in Eilean Gartmeal. They are generally granular-crystalline, dark blue rocks, and vary in thickness from two or three feet up to several yards. Some of them

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trend approximately north and south, or a little east-by-north and west-by-south, as at Port Skipness, while others strike from north-by-west to south-by-east, as in Gartmeal.

Glaciation and Glacial Deposits.—Although the hills of Colonsay are frequently rugged, and present generally a rough, irregular surface, yet one has no difficulty in detecting the flowing and undulating features which are the characteristic results of glacial action. The rocks present us with, if I may so express it, a double configuration. They show us first the contour assumed by the strata under the influence of the subaërial forces in pre-glacial times, while, superinduced upon that surface and partly obscuring it, we find the outline acquired underneath a continuous flow of glacier-ice.

Throughout Colonsay the prevailing strike is north-east and south-west, and the dip is generally, although not always, towards the south-east. This arrangement of the strata gave rise in old pre-glacial times to a series of parallel ridges and hollows which traversed the island obliquely in the direction of the strike—the ridges presenting their steeper faces or escarpments towards north-west or south-east, according as the strata cropped in one direction or the other. These alternating ridges and hollows, due of course to the unequal yielding of the rocks to the denuding forces, can still be readily traced throughout the greater portion of the island. In the south of Colonsay and in Oronsay, where the strike frequently changes, a corresponding change takes place in the direction of the "ridge and furrow," and sometimes all evidence of old escarpments and intervening hollows has disappeared, or probably these never existed.

In glacial times the whole island was overflowed by ice, which has smoothed away or bevelled off the sharp escarpments, so that these now show as somewhat rounded ridges. But the rocks are so readily attacked by the weather that they easily succumb, and the *roches moutonnées* are rapidly tumbling into ruins. It is, therefore, only when the hills are scanned from some little distance that their glaciated outline becomes conspicuous. Near at hand they are so broken up and weathered that one not familiar with the aspect assumed by a glaciated country might possibly never suspect that they had at one time been overflowed by glacier-ice. Nevertheless, a careful examination will detect here and there not only well-smoothed but well-striated rock faces. Owing, however

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to the readiness with which the rocks weather, glacial striae are not common; but I met with them at various levels from the coast up to the very highest point of Colonsay. They agree in general direction, and run from north-east to south-west—the trend varying from W. 12 S. to W. 25 S. In the extreme south of Colonsay, on the shore near Garvara, the direction was only 4° or 5° south of west. On the hills to the north of Baleroman Dubh the striae pointed to W. 15 S.; near Loch Sgoilte, to W. 20 S.; and within a few feet of the top of Carn-nan-Eun (493 feet), the highest hill in Colonsay, to W. 25 S. I noted also a number of smoothed rock-faces on the hills east of Carn-nan-Eun, and between Loch Fad and Schallasaig. Similar smoothed faces occur at Baleroman Dubh and near Dun Coll, but on all these the striae were indistinct or entirely obliterated.

Boulder-clay or till of a typical character is met with here and there in the hollows throughout Colonsay and Oronsay. It is usually a reddish-coloured, gritty clay, quite unstratified, and abundantly charged with angular and subangular glaciated stones and boulders. Not a few of these showed very finely striated surfaces. In addition to numerous fragments of schistose and gneissose rocks, which may be, and most likely are, of local origin, there are boulders of granite, limestone, porphyrites, red gritty sandstone, and red conglomerate. The granite closely resembles that of Loch Etive, and has, most probably, come from that region; the limestone is blue, and of the same character as that of Lismore; the porphyrites I recognised as precisely similar to the Old Red Sandstone igneous rocks of Kerrera and the neighbourhood of Oban; the red grit, or coarse pebbly sandstone, and red conglomerate, came, I do not doubt, from the same district. Besides these, I noticed one boulder of a peculiar purplish, variegated limestone-breccia, which I have not seen *in situ* anywhere, but it may very well have been derived from the Garvelloch islands, where rocks of this character are said by Macculloch to occur. Thus the "carry" of the stones in the till of Colonsay goes to corroborate the evidence supplied by the glaciated rock-surfaces, and points to a movement of the ice from the mainland in a south-westerly direction.

The distribution of the till in Colonsay points to the same conclusion. It is found sheltering behind hills and projecting rocks whose bare faces look towards the north-east; while from all places

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which must have been exposed to the full brunt of glacier-ice flowing from the mainland it is entirely absent. Some good exposures of it occur in the neighbourhood of Loch Fad and Colonsay House. As a rule, however, it is very patchy and interrupted, never forming continuous sheets, but occurring as mere heaps and scrappy sprinklings in sheltered nooks and hollows. It is as hard and tough, however, as till usually is.

The glacier-ice that overflowed these islands has left another well-marked feature behind it in the deep rock-basin that lies along the inner margin of Oronsay and Colonsay. This basin has been excavated to the depth of 115 to 120 feet below the general surface of the sea-bottom between Colonsay and Jura; and the deepest part of the basin lies close to the shores of Oronsay and Colonsay. This, of course, is only what one might have expected, and is paralleled by similar phenomena all through the Inner and Outer Hebrides.

Raised Beaches.—The only raised beaches occur at comparatively low levels. The highest one I saw hardly attained 50 feet above the present sea-level. They consist of banks of rolled stones and boulders, or coarse shingle. One of these is seen at Ardskinish Point, and another in the south of Oronsay. All the low grounds of the latter island, indeed, appear to have been reclaimed in recent times from the sea. One looks in vain, however, for any evidence of great post-glacial submergence, such as we might have expected to meet with had the island been drowned to much greater depths than 50 feet.

Blown Sands, &c.—Along the west coast, as at Killoran Bay and Traigh-na-Bairce, and in Oronsay, there are considerable accumulations of blown sands, and the adjoining shores are low, flat, and sandy. As these sands contain a considerable admixture of triturated shell-*débris*, they yield a fertile soil and support a beautiful sward. Sandy beaches are by no means so common on the east side of Colonsay, which in this respect contrasts strongly with the west. The enormous quantities of sand which are found upon the outer coasts of so many of the Inner and Outer Hebrides can hardly be derived from the denudation of the rocks exposed upon the shores, but, as I have endeavoured to show, in a paper recently read to the Geological Society of London,* probably result

* *Quart. Journ. Geol. Soc.*, Vol. xxxiv., p. 859.

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from the washing-up of those upper or more recent glacial deposits which must cover wide areas of the sea bottom, especially outside of the islands. It is the sand derived from these submerged deposits which the Atlantic sweeps in towards the islands, and with which it is gradually silting up many bays and channels.

Explanation of Plate V.—Geological Map of Colonsay and Oronsay. The topography is reproduced from the Admiralty Chart. The heights on land are given in feet, and are denoted by the larger-sized figures. The smaller figures indicate the angle of dip of the strata—the direction being shown by the smaller arrows. The larger arrows with a circle give the direction of glacial striae. The syenitic rocks near Killoran Bay, and the granitoid rock of Schallasaig, are denoted by the small patches of horizontal shading; and the dykes of basalt rock are indicated by short black lines. The figures in the sea are fathoms—the shaded area showing the extent of the submarine rock-basin.

[NOTE.—I am indebted to Rear-Admiral Bedford, R.N., for kindly allowing me to inspect his field-sketches and observations made by him during the Admiralty Survey of the West Coast of Scotland. From these he has permitted me to extract the following valuable notices of Raised Shingle Beaches observed and sketched by him. The heights are given in feet above high-water:—

Oronsay,	39·
Jura, South Coast, in Sound of Isla, south of Knocbreac Loch,	34·8
,, West Coast, South of Loch Tarbert,	109·
,, ,, Loch Tarbert, South Coast of,	42·1
,, ,, ,, North Coast of,	105·5
,, ,, ,, ,,	19·
,, ,, North of Loch Tarbert,	4·
(Much Shingle on this part of Coast).	
,, ,, North from Rudha Sailean (no heights given).	
,, ,, Sian Bay—several Beaches here,	133·
,, ,, near Traigh-nam-miada,	111·
,, ,, ,, ,,	122·
Lunga,	40·8
Black Isles (no height given).	
Kerrara,	40·10
Tiree, east end, four Raised Beaches,	20 to 30·
Ballachulish (narrows),	42·
Loch Etive, north entrance (no height given).	
Annat, Loch Eil,	42·
Corran, Loch Aber,	42·]

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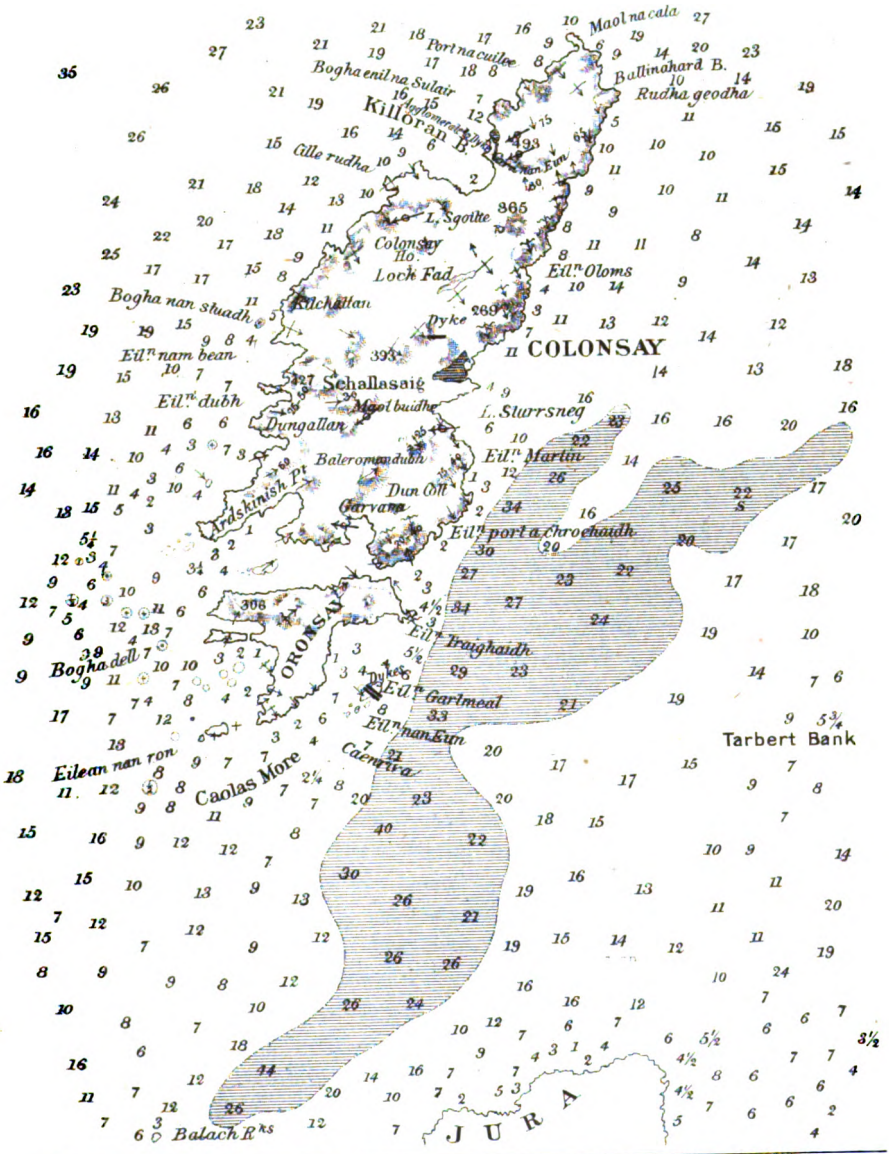
GEOLOGICAL MAP OF COLONSAY AND ORONSAY



Explanation of Signs etc.

- *Horizontal Strata*
- *Gently inclined ,,*
- *Nearly vertical ,,*
- *Contorted ,,*
- *Inclined ,, (figures denote angle of Dip)*
- *Direction of Glacial Striæ*
- *Basalt Dykes*
- *Granitoid Rocks*
- *Heights on land given in feet*
- *Depths of Sea given in fathoms.*
- *Shaded portion indicates a Submarine Rock Basin*

ROBERT GARDNER & CO. LITH.

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XX.—A German Professor's Views *of the* Geology *of* Arran, *translated from* Prof. A. von Lasaulx's "Aus Irland," Bonn, 1878, with Remarks, by Edward A. Wünsch, F.G.S.

[Read 5th December, 1878.]

First Part.

[A visit by Professor A. von Lasaulx, of Breslau, to the Glasgow meeting of the British Association in 1876 has resulted in a book entitled as above, recording chiefly the geological investigations of the author in Ireland, where he made a more lengthened tour under the guidance of our late Vice-President, the present Director-General of the Geological Survey of Ireland, Professor Edward Hull, to whom the book is affectionately inscribed; but the two last chapters are devoted to the geology of Scotland. In his introductory remarks under this head the author is full of graceful acknowledgments, and has a word of praise and thanks for every one from whom he derived information, printed or oral. In connection with the geology of the West Coast and of Arran, honourable mention is made most prominently of the members of the Geological Society of Glasgow, and Messrs. Armstrong, D. Robertson, Young, Thomson, and Wünsch are each quoted and thanked in turn for the information supplied. For general geology Professor Geikie's "Geology of the British Isles," so far as it relates to Scotland, seems to have been the author's chief guide, and the views of the Director-General of the Scottish Geological Survey are endorsed, or, at all events, not controverted in any essential point. In the first chapter, relating exclusively to the geology of the mainland, Professor von Lasaulx does not advance any special theories of his own; in the second chapter, however, devoted exclusively to Arran, the authorities are not so numerous, and the author seems to have carried out his personal investigations with peculiar vigour. Dr. Bryce is quoted here and there, but the author does not seem to have derived much satisfaction from his views, and is not long in brushing them aside, and in advancing a theory of his own in place of them. In this theory the chief interest of the book centres, so far, at least, as our Glasgow geologists are concerned, and I propose accordingly to give a careful translation of this portion, merely premising that the preceding

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chapter contains a masterly review of the geology of the west of Scotland, a translation of which may be of interest at some future time.]

The island of Arran has been much visited and much described by geologists, and many English, French, and German travellers have investigated the district, so that it might be thought another visit would not readily disclose any facts not hitherto observed.

But Arran is in a certain sense inexhaustible, and thus also occurred to us, during a short visit to this beautiful island, various considerations as to its geological structure and outlines which might open up some new points of view, offering a more easy solution of its complicated and not yet readily understood geological details than has hitherto been presented. Arran may truly be described as a portal of honour placed at the entrance to the beautiful shores of the Clyde.

Starting from Rothesay, and sailing past the south end of Bute into the expanding estuary of the Clyde, the beautiful profile of Arran, stretching from north to south, lies right before us. At the first glance, this profile discloses to us a portion of the interesting geological structure of the island, upon which structure is also based the secret of its picturesque outlines. The island presents itself in two aspects, entirely different in their forms of relief—on the right, the high, sharp, serrated granite peaks, on the left, the lower, almost wall-like, elongated backs of the Old Red and Carboniferous formations, covered by the newer eruptive rocks.

The northern or higher part of the island has entirely the character of wild highland mountains, whose jagged peaks are surrounded by steep, almost perpendicular gullies. The whole region may be divided into two separate chains, running parallel north to south, separated to the south by the deep Glen Iorsa, and to the north by Glen Eais-na-Vearradh. The eastern chain is not so distinctly articulated as the western. It consists of an irregular group of granitic peaks, chiselled out of one massive granitic structure by powerful erosion. Amongst these the highest is Goatfell, the landmark of the island, raising its proud head 2866 feet above sea-level; the next highest peak is Caistael Abhael, lying to the north-west of Goatfell, and between the two the peak of Cior Mhor rises to the height of 2618 feet. The western chain has entirely the character of a regular mountain chain, but has no such considerable heights as the eastern one. Meal-nan-Damh

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reaches only 1870 feet, and the heights rising from Glen Iorsa only 1500 feet.

What has chiefly made Arran interesting to and famous amongst foreign geologists are its trap dykes, and still more so its pitchstones—that vulcanic glass in which the most wonderful formations of slags (glassy slags) of our furnaces are foreshadowed (typified) in such a manner—but rarely repeated in such perfection in other rocks—that these analogies lead to the irresistible conclusion as to the plutonic origin of this rock. Numerous descriptions have made known to us the beautiful fern-like tufts, the brocoli-like bunches, and the neat snow-crystal-like groups in which embryonic crystalline spikelets of augite are aggregated in these pitchstones. The geological position of these pitchstones is of great interest, too, and their study was the chief object of our excursion to Arran. The most favourable appearances of pitchstones, which are everywhere in close local connection with quartz porphyry, and hornstone-like dense felsite, are, on the east coast of Arran, near Clachland Point, and on the west coast, south of Tormore, at Drummadoon Point—also in dykes on the shore near Brodick. To the first of these points, which can be visited from Brodick comfortably in two to three hours, we now turn, and with it can be combined usefully on the return journey a ramble along the coast, which is crossed by dykes in every direction.

Ascending the road at the back of Brodick pier, we reach the terrace leading to the heights of the Dundhu range, a rounded, elongated range of hills, averaging 600 to 700 feet in height, superimposed upon the sandstone terrace which bears the fruitful fields and pastures of Corriegills. The highest point of this range is Dun-fion hill, and the northernmost end of the ridge projecting steeply into the sea is Clachland Point.

And here we are at one of the points at which the classical pitchstones of Arran are to be seen to the greatest advantage.

Proceeding at the back of the Corriegills farms, along the Dundhu range, towards Dun-fion, a series of rocks is traversed, the profile of which has already been given by Dr. Bryce, although in a somewhat greatly-idealized diagram. [See "Arran," page 80.]

Nethermost are the conglomerates and sandstones of the Upper Old Red. The highest layers of these sandstones appear at first sight to be separated by conformably intercalated beds of quartz porphyry and pitchstone, so that, according to Bryce's profile,

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counting from below, the following almost horizontal beds overlie each other:—Sandstone, quartz porphyry, pitchstone, sandstone, pitchstone, and uppermost, basaltic trap, so that we might in effect believe to have before one's eyes a regular mass of strata made up of a series of sandstones and pitchstones.

[This view is controverted by the author at greater length than it may be convenient to give it here, so I omit it.]

The two pitchstone dykes, of about equal thickness, of from 13 to 14 feet, can be followed pretty far down the cliffs. The appearance of this rock must be familiar to all; but what is striking about it is a very plainly-marked parallel, sometimes slatey, fracture, which makes it difficult to get good hand specimens out of the brittle material. This thin-plated fracture is, however, not the same in all places. Following the southernmost dyke in its downward course, it can be traced, with some interruption where it is covered by vegetation, down to the sea-shore.

Descending now from the upper sandstone terrace of Corriegills down to the conglomerate beds which form the sea-cliff proper, a walk along the foreshore, bounded by the massive walls chiselled out of the sandstone, and extending as far as Brodick, affords an excellent opportunity of obtaining an idea of the almost innumerable dykes which here everywhere intersect the strata of the Old Red. In the short space of about 4½ miles from Clachland Point to Invercloy hotel about 60 may be counted, mostly greenstone and basalt; but the microscopical examination of which will probably disclose further petrographic differences. Interspersed between them there also appear very massive dykes of quartz porphyry and of dense felsite, as well as the dykes of pitchstone already referred to.

At the edge of the terrace the (trap) dykes are seen rising like chimneys. On the level shore they mostly form straight massive furrows or wall-like prominences, according as the rock may weather more quickly or more slowly than the surrounding layers of Old Red. The dykes can be followed by the eye below sea-level, and at low tide there is a matchless geological exhibition prepared by the waves themselves with an infinity of toil. And still this richness in dykes is not peculiar to Arran. It is only a repetition of the same occurrences which we noticed in Ireland at Belfast, and in Scotland along the shores of the Clyde; but the grander exposure in Arran conveys a stronger impression of the picture.

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Not less interesting than this southward wandering is an excursion from Brodick hotel to the north.

Long before the terrace on which the castle stands is reached, a whole series of dykes has been traversed, amongst which must be mentioned the pitchstone dyke at the schoolhouse at Brodick—possibly a continuation of the Corriegills dykes.

But the special interest of an excursion farther north along the coast is connected foremost with the appearance of a rich series of beds of the coal formation, and of beds of volcanic ash included in these. Especially north of the "Fallen Rocks"—an old massive slip of a mountain side of blocks of Old Red—have these beds chiefly become known by the investigations of Messrs. Wünsch, Young, and Thomson.

[And here I may be allowed to skip a certain portion of the original text as relating to myself, and in fact taken—of course with full acknowledgment—from the *Transactions* of our Society.]

From Lagantuin Bay forward to the north end of Arran—the Cock of Arran—where the red sandstone, formerly considered New Red, occurs again, there is laid open a series of beds, consisting alternately of layers of limestone, calciferous sandstones, shales, thin seams of coal, so-called ash-beds, and variously composed breccias and conglomerates, in which the fossils of the various stages of the Coal formation are found. The ash-beds—which, according to their petrographic character, we should prefer to designate diabasic tufa—lie everywhere intercalated conformably between the sandstone and shales of the series, and are in part distinguished by the numerous remains of plants, and also of fish, contained in them.

One of the best points for their study lies somewhat south of Lagan, in the neighbourhood of which large slate quarries are laid open. This is the point to which, in particular, Mr. E. A. Wünsch's discoveries have lent interest. Here he found, in the year 1865, in these greenstone-like ash-beds—to retain his own expression—numerous stems and branches of trees. The more particular botanical definition and description have been afterwards supplied by Mr. Binney, of Manchester. The beds—alternately sandy shales, thin seams of coal, and peperino-like tufa—are inclined at an angle of 30° to 60°; the trunks, of which 12 to 14 have been found, stand horizontally upon the plane of the beds, and are rooted in the earthy layers of the shale, several series of trees overlying each other. The branches and leaves are excellently

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preserved. We saw the finest of the specimens in the collection of Mr. Wünsch in Glasgow. They are *Sigillaria*, *Lepidodendron*, *Halonia*, *Sphenopteris* and other ferns. A new species of *Lepidophloios* has, in honour of the discoverer, received the name of *L. Wünschiana*.

Undoubtedly the beautiful geological profile presented by this portion of the shore offered an excellent illustration of the alternation of geological events by which these strata were formed. To quote the words of the discoverer, "Slowly the volcanic ashes enveloped the plants growing in low marshy ground." Such occurrences were repeated throughout the whole immeasurable time of the Coal formation—for the alternation of sandstones and limestones, some of them containing the thoroughly characteristic and extremely well-preserved fossils of this formation, as well as the intercalated volcanic ash, extends, as already stated, from Lagantuin Bay to the Cock of Arran—so that from this the thickness of the Coal formation of Arran, chiefly of the lower series, may be estimated as exceeding 6000 feet. But numerous elucidations will not be required as to the connection and true position of the many single series extending along the north coast of Arran. And here it will be of special importance to remain mindful of the probability of various faults, or upthrows and downthrows, which, according to the views we have developed as to the general structure of Arran, are extremely probable. Thus, already the red sandstones of the Cock of Arran, formerly held to be New Red—Bunter-sandstein—as they appear to overlie the Carboniferous strata, have been recognised as true Old Red, and are marked as such on Geikie's new map of Scotland. Therefore this spot affords a clear example of an apparently reversed succession of series, for the strata underlying these red sandstones are by their fossil remains very decidedly characterised as Lower Carboniferous limestone. Thus, the whole west coast of Arran—at which only a short peep was allowed us—as also to a certainty the whole island, offers still a rich field for geological labour and investigation.

Thus, when we stepped on board the magnificent screw-steamer "Arbutus"—which had brought many hundred guests of the Meeting of the British Association to Arran, and by the return of which we profited—and when the evening sun showed to us in splendid illumination the curious shapes of the Paps of Jura wrapped in distant purple glow, and as we gave a last look at the

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lovely island, as it was gradually veiling itself in its evening mists; then, in bidding it farewell, we united with our adieux the wish and hope of *au revoir*, for no one would like to think that he shall have seen Arran for the last time.

Second Part.

[I have somewhat transposed the order of contents of the original chapter, and I have reserved for the Second Part the specially-interesting remarks of the author respecting the granitic, and, indeed, the general structure of Arran—the First Part being merely descriptive and introductory, and what now follows being intended as the kernel of my paper. The author, literally translated, writes on this subject as follows, p. 222].

What has most occupied English geologists, and has appeared to them as most striking and remarkable in the structure and distribution of the rocks of Arran, was the abnormal, one might say the eccentric, position of the granitic masses in the northern portion of the island. In connection with this it was always assumed as though the granite, breaking through, had been the upheaving cause—the force that had uplifted the island on its shoulders. We have already seen by examples in Ireland, following the indications of Continental mountain chains, that this upheaving force is not in any sense to be understood as a radial force, working from below upwards. If here also, in place of this protrusive raising force, we assume a sideward pushing tangential effect of pressure, then the eccentric position of the granite in itself has no longer any meaning; and that the peculiarities of mountain structure in Arran fit into the assumption of elevation produced by tangential pressure is brought out more particularly when we consider this island not as an isolated unit by itself, but in connection with the rest of Scotland and the opposite coast of Ireland. The remarkable and uniform direction of the mountain chains and of the strike of the strata from S.W. to N.E., which we have found everywhere prevailing in Ireland, is also continued in like manner in Scotland. A line drawn from Belfast Lough to the Scottish coast, exactly in the bearing of S.W. to N.E., will strike straight upon the boundary line between the massive beds of Silurian strata and the old crystalline schists which extend from Money Head, on the peninsula of Rhinns of Galloway on the west coast, to St. Abbs Head on the east coast. North of this zone lies the district of the sedimentary

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formations from the Old Red downwards, principally the Carboniferous formation and its associated massive trap rocks, which reach from the neighbourhood of Glasgow to the hills around Edinburgh. In Ireland, north of the Silurian strata in Lagan Glen, lie the basaltic formations of County Antrim. According to their position these could therefore be held to be the equivalents of the beds between the Firths of Clyde and Forth—that is to say, they correspond in direction to one and the same area of depression. If we now again draw a line across to Scotland, farther north-west from the boundary of the old crystalline schists and the younger formations at Lough Foyle, this takes us exactly to the boundary of the sedimentary strata of the Old Red of the neighbourhood of Glasgow, and abutting against the northern-lying Silurian formations. The old crystalline schists of Donegal, lying north-west of Lough Foyle, in which may also be included the portions in the north-west corner of County Antrim, correspond therefore to the Silurian formations of Kintyre, Argyllshire, and the Grampian mountains, which they almost literally touch in the N.E. point of Antrim.

Thus we obtain a tolerably clear view of the connection of geological structure between the north of Ireland and Scotland. It shows to us that the two countries correspond perfectly—that from south to north there is an even succession of the gigantic folds of the old surface dividing the country into ridges and valleys. Thus the level plain of the Carboniferous limestone in the centre of Ireland corresponds to the Carboniferous limestone of Northumberland. The zone of the Silurians and of the granites of the Mourne mountains corresponds to the zone of the Upper Silurians between Money Head and St. Abbs Head. The series of the Antrim beds, with its eruptive rocks overlying here also the Carboniferous formation, corresponds to the whole series of formations between the Clyde and the Forth; and finally the Silurian schists of Donegal, described as metamorphic schists, correspond to the Lower Silurians of Kintyre and of the southern Highlands of Scotland. With regard to these latter, it certainly may be inferred that the crystalline schists of Donegal and 'Derry, marked in the map of Jukes as metamorphic series, may also belong in part to the Lower Silurian, although this has not yet been so definitely fixed as has been possible on the opposite coast of Scotland. If we then distinguish these two zones of Silurian rocks and of old crystalline

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schists, on which we here lay particular stress, and which, to adopt a compound geographical name, we might call the *Donegal-Argyllshire* folds or ridges, and the *Lagan-Dumfriesshire* ridges, we find that within these two zones there are embedded in a remarkably uniform manner large masses of granite.

Those in Ireland are the extensive granitic mountains extending from Gweebarra Bay on the west coast to the outflow of Lough Swilly, and to these in Scotland correspond the numerous granitic masses which succeed each other from the Firth of Lorne across to Kinnaird Head, and have their greatest extension in the east in Aberdeenshire. In the southern zone it is in Ireland the granitic mountains of Mourne, and in Scotland those of Kirkcudbright.

All these granites come to the surface in more or less elongated elliptical patches, and adjoin each other in a direction parallel to the general strike of the large mountain folds (the large Λ ridges and V troughs of the mountains). In other words, the granites lie upon lines at right angles to the lateral pressure which has produced these folds.

Thus the appearance of these granitic masses at the surface is probably to be accounted for (simply) by the violent compression of the old Silurian strata covering the granites, and by their extraordinary folding, and the complete shattering and bursting open of the folded domes—thus laying open the underlying granites. Later on, by means of powerful and long-continued erosion, the granite became more and more detached from its surrounding envelope and was laid bare in high pointed peaks. Nowhere can the granite be looked upon as the lifting power, but it was itself pushed and raised up along with other rocks.

All these considerations may be summed up in a few words to the effect that a force pushing in a north-westerly direction, and meeting with resistance in a direction from the south-east, induced an upward and downward folding (or undulation) of the surface. The upraised parts (or Λ) are seen in the Silurian districts which have not been covered by later formations, while the depressed or sunk parts (V) were filled up subsequently, more or less completely, by the whole series of sedimentary formations, which in two distinct repetitions are seen spread out in tolerable uniformity between these two uprising Silurian folds from the south of Ireland to the north-east point of Scotland.

Thus one could easily sketch a profile of the characteristic wave-

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lines common to both kingdoms, the one-half of which would be represented as near as may be by the profile [p. 202].

These considerations, then, prepare the way for the understanding of the mountain structure of Arran. Right through the centre of the island runs the boundary line between the old elevated fold, or ridge (anticlinal axis), which we have designated as the Donegal-Argyllshire ridge, and the sunken area (or synclinal trough), which has received the sedimentary formations between Clyde and Forth. In the northern part of Arran a mighty mass of granite has been laid bare from between the shattered Silurian schists that lay round about like a cloak. Hence the position of the granitic mass in the northern part of the island is not "abnormal," and has nothing to do with the shape of the island. Hence the granite is not a "mineral axis" [*vide* Bryce's Arran, p. 6]—a designation to which I cannot attach any correct meaning; it is only the projecting portion of the ridge which extends uniformly over the whole of Scotland as far as the east coast. Thus also the structure of the southern part of Arran is entirely in conformity with the opposite district of Renfrewshire, where the Old Red and Carboniferous series follow each other from north to south precisely as they can be followed between Loch Katrine and the Campsie fells. The line, which may be drawn as the boundary line between the raised and the depressed portions of Arran, begins opposite in the Mull of Kintyre, goes straight through Glen Iorsa, and thence bending somewhat northerly to the Cock of Arran, cuts straight across to Rothesay, which likewise is situated on the boundary between the Silurian schists and the younger sedimentary formations, consisting here of the Old Red Sandstone. Thence the boundary line runs in a north-easterly direction almost straight across Scotland as far as the bay of Stonehaven.

That the structure of Arran and the position of its granites is to be taken in this sense may perhaps be further best evidenced if we take one of these granitic masses lying near the southern edge of this Silurian zone, and look upon it as a detached insular mass. We then have an island, the structure of which is in conformity with that of Arran. North-east of Comrie lies the granitic peak of Ben Chonzie, 3048 feet high. If we draw around it an ellipse, extending southward into the Old Red district, and imagine this to be an island, it would show us the exact structure of Arran; like it, there would be an elevated northern granitic portion, sur-

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rounded by Silurian schists, and in the south the sedimentary basis of the Old Red, with its superimposed eruptive rocks. The position of Comrie, on the boundary of the southern area of depression, is of particular significance, inasmuch as the neighbourhood is subject to numerous and quickly-recurring shakings of the ground, which prove the continuance of the movements of the earth's crust upon this line up to our time. Thus the great variety in the geological positions in Arran is not a peculiarity, as has been hitherto maintained in all descriptions of it; for if the variety is an effect of the boundary line between the raised and the sunk areas running across the centre of Arran, it cannot be admitted to be the effect of a peculiar abnormal position of the granitic nucleus. It does not correspond in the remotest degree to the assumption which attributes the structure of the island to the breaking out of a massive body of eruptive rock, such as the granite is said to be, along the line of junction of the older schists.

In fact, in Arran are repeated the same circumstances (or geological positions) which have been observed along the boundary lines of sunk areas in other districts; hence, along this boundary line the steep and partially-upturned position of the sedimentary rocks, as observable in the northern part of Arran; hence, also, the great mass of younger eruptive rocks which abound in the sunken area of Arran in every direction.

Thus Arran, surrounded by the sea, has in a manner remained as a connecting link between Scotland and Ireland to show that, geologically speaking, no rolling channel separates the two countries. And, as thus it proves most effectively its geological connection with the opposite shores of St. Patrick's Channel, so, on the other hand, the peculiarities of its structure can only be understood when the island is taken, not as a separate, independent area, but is looked upon as an integral part of the whole geological structure of North Britain.

Third Part.

[In making a few remarks upon the foregoing subject, I would beg of you to bear in mind that, with the exception of some introductory remarks of my own, every word of the foregoing—descriptive and explanatory of Arran and its granites—is a translation of Prof. von Lasaulx's paper, purposely kept as literal as possible to do every justice to the author.

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Throughout his paper Prof. von Lasaulx never once propounds any theory of his own as to the origin of the granites, nor any mineralogical or chemical theory in connection with such origin. He confines himself strictly to describing the stratigraphical position of the granite, and the only theory he advances is what may be called the physical or mechanical one—namely, that the present surface appearance of the Arran granites is not to be taken as an isolated occurrence, but is only one example of a series of appearances extending over a great portion of Scotland, and across and under the Irish Channel into Ireland, in the shape of gigantic ridges or folds—wave-like swellings of the earth—with alternating elevated crests or anticlinals, and correspondingly depressed troughs or synclinals, running in parallel lines from N.W. to S.E.—the upper surface mostly covered by Silurian rocks, but the granite laid bare here and there in large elliptical patches, a typical example of which is offered to us by the group of the Arran granitic mountains. Now, when we look at the geological maps of Scotland and Ireland, we are bound to admit that, so far as external appearances are concerned, the author's description is correct, and that he has succeeded in bringing before us a splendid generalisation, supported by close reasoning and by reference to actual positions on the map, and the whole more clearly and more powerfully expressed than has been done by any previous writer. In fact, the stratigraphical position of the granites, as laid down by the author, is unassailable, and, like a prudent general in advancing into the open field, he lays himself open to the least possible attack by advancing only one single theory—which is, that the present appearance of the granites, and of the overlying schistose rocks, running across the country in enormous parallel waves, *is due to lateral pressure.* Had Prof. von Lasaulx confined himself to this statement, no one, looking at it in a general way, could have denied it; but in connection with this theory he also introduces the question of time, and infers that these enormous plications took their origin so far back that, while the ridges formed mighty domes to be hereafter sculptured into separate mountain systems, the corresponding depressions were so vast and deep as to admit of the deposition of sedimentary strata during the Old Red Sandstone period; and there he certainly lays himself open to attack. We cannot advance against him a theory more comprehensive than his own, or one corresponding better to the

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apparent stratigraphical position on Prof. Geikie's map; but we can show that his theory in its integrity is untenable, because it is irreconcilable with facts, of which ocular demonstration can be given.

I may here refer only very briefly to a paper which was read at the Glasgow meeting of the British Association in 1876, on the junction of the Old Red and the granite at Arran, its purport being to show that the hitherto assumed bands of slate entirely surrounding the granitic nucleus were imaginary, and that there was a direct and unbroken succession from the Old Red into the granite, as could be clearly shown to even a geologically-untrained observer, by leading him up from North Sannox Burn in the direction S.W. as indicated by my map (enlarged from the Ordnance Survey map), showing the Old Red Sandstone rising to the height of more than 800 feet in one unbroken series of stratifications, until it is clearly seen to gradually merge into and assimilate with the great mass of granite forming the central part of the island. All theories and statements to the contrary notwithstanding, I assert that the granite facing east on both sides of Glen Sannox, and in the adjoining corries south, *retains traces of stratification with the same general strike and dip as the adjoining beds of Old Red which supplied the material now metamorphosed into granite.*

There is therefore clear proof that the Arran granite, such as appears on the eastern coast, is *posterior* to the deposition of the Old Red Sandstone, and the sweeping generalisation of Prof. von Lasaulx becomes untenable in point of time. An additional and overwhelming proof that the Arran granite in its present position cannot be *anterior* to the Old Red, is furnished by the well-known fact that at the N.E. end of Arran the whole of the Carboniferous series, and the underlying Old Red, are upheaved on the flanks of the granitic nucleus, some of the beds (as near the Saltpans) at a very steep angle, and to the height of more than 600 feet. In controverting this point, and meeting it successfully, as I hope, the question raised for discussion, so far as Prof. von Lasaulx's paper is concerned, is disposed of, and we are thrown back upon the almost untouched and still unsolved question as to *the origin of granite.*

I may be allowed, in conclusion, to express my admiration of Prof. von Lasaulx as an accomplished geologist and author, and

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to add the hope that he may be induced, at no distant time, to re-visit the scene of his labours in Arran; and that we ourselves, as members of the Geological Society, may, by further investigation and study, be prepared to meet him once more, and show ourselves "foemen worthy of his steel."]

XXI.—*On the* Rocks *and* Graptolitic Shales *of the* Moffat District. By James Dairon, V.P.

[Read 16th January, 1879.]

Having on several occasions described the rocks of Moffatdale to the Society, I shall confine my remarks to-night to a few minor details connected with them, aided by a number of hand specimens I have brought for illustration.

It may safely be asserted that few other stratified rock formations have undergone such an upheaving, crushing, and contorting, as the Silurian, for its strata are to be found tilted from their original level at all angles—up to the perpendicular, and even inverted. Occasionally the folds take many strange and fantastic forms, as is more particularly the case with the black mud-stones or graptolitic shales.

The prevailing rock of the district round Moffat is Silurian grit or grauwacké, the whole of the hills being chiefly composed of it, and its accompanying thin flaggy grits and graptolitic shales, which crop out frequently at certain points along the valleys. These rocks also stretch right across the country, from an anticlinal axis at Birkhill to the Irish Sea on the one shore, and to the German Ocean on the other.

The hills built up of these rocks are all verdure-clad to their summits, except where they are scored and cut into by the mountain streams.

The grauwacké is largely used in the neighbourhood for building. I exhibit a specimen from Wellhill quarry, which is said to be the best in the district for such purposes. It is crystalline in texture, and is of a fine grey colour, but varies according to locality, being sometimes of a reddish or purplish tint. It is hard, tough, and durable.

Here is a red sandstone, said to be of Permian age, and

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evidently the equivalent of the Corncockle Muir sandstones. It probably covered the district to a certain extent, but has been afterwards largely denuded away, the portions now remaining having been protected by their peculiar situation. Great quantities of the sand, formed by the disintegration of this rock, are found in many places, and are used for building purposes.

In this red sandstone are found embedded large and small fragments of older rocks which have been deposited in the strata while they were still in a soft and pasty condition. Its greatest exposure is to be seen on the way up to Hartfell, on the side of the burn which has cut through it, but it is also found in many other places, as on the Well burn, Frenchland burn, Beld craig, &c. It is soft, shivery, and brittle in character, and apparently unfit for any economic purpose whatever; its appearance being as if it had not received sufficient pressure, or wanted some cohesive ingredient to give it solidity. In some places it is stained with white circular markings, having a small central nucleus similar to those common in the Old Red Sandstone. Its equivalent at Corncockle Muir is an excellent building material, and is largely used for the dressings of buildings, and for foot pavements.

These specimens of upper graptolitic black shales are from Dobb's Linn, and are crowded with graptolites. This rock is soft and aluminous, does not split freely in many places, and is generally more folded and contorted than the lower shales. A fine section of one of these foldings may be seen from the head of the long arm of Dobb's Linn. The burn passes through it as through a broken archway, the top having been denuded away, possibly by some great flood. A short way further up there is another example of a similar folding which the burn runs through, the top having been also broken away, and the bed of the stream drops about 15 feet just at the spot, forming a small cascade, so that the effect produced is very fine.

This specimen of upper shale is taken from the extreme end of one of these foldings, and is full of fossil remains. At the same point the shales are in vertical bands of about three feet across, and are all jointed at right angles to the plane of lamination, but these joints occur at irregular distances of from 1 to 8 inches or so. Here there is found between each of the 3 feet bands a layer of light-coloured clay from 1 to 2 inches thick. In places where this becomes freed from the shale, it washes down, and, mixing with the

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rock *débris*, forms a hard breccia, found in some places in considerable quantity.

The fossils in the upper shales belong to the genera *Monograptus*, *Rasterites*, *Diplograptus*, and *Retiolites*, with some crustacean remains, and one or two Brachiopoda I got lately, also *Serpulites dispar* (Salter), and all in a beautiful state of preservation. I mentioned in a former paper that I had observed a number of small faults in the cleavage joints, so that, when a slab is split, one part of a graptolite may be seen, while the other portion is on another plane either above or below.

As may be seen from the specimens on the table, the lower shales are very much harder than the upper ones, and are usually not so much contorted or folded. Slabs of a much larger size can be obtained from them, and they split much more freely at any thickness of layer down to the 1-16th of an inch. They are also generally quite free from the aluminous matter so abundant in the upper shales. Curiously enough they give off a very pleasant odour when closely shut up—as in a cabinet drawer—for any length of time. Whether this is due to the great quantity of organic matter they contain or not, I am not prepared to say.

The finest section of the lower shales to be found near Moffat is at Hartfell, on the north side of the burn, opposite the Spa—or, in other words, on the left-hand side, looking up the corrie. A low cliff about eight feet high, of the same rock, runs along the top of the section to the end of the corrie, nearly a quarter of a mile long, and about 40 feet below the upper crag. There is another parallel to it, and then a talus of *débris* to the bottom. From the bed of the burn to the top is fully 300 feet. The principal fossils of these shales are the branching forms—*Pleurograptus*, *Diplograptus*, *Retiolites*, and portions of *Eurypterus*, &c. One bed of shale associated with these rocks does not split up, but, as I have mentioned before, falls into small tabular pieces—a characteristic caused, doubtless, by metamorphism, probably through the action of hot vapours.

The physical characters of such localities as Dobb's Linn must alter very much in the course of a few years, owing to the shattered state of the black mud-stones. From the action of the rains and frosts upon their numerous jointings they are being split up and thrown down into the stream below, and then washed away by the floods. When up at Hartfell last summer I noticed that at the

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head of the corrie a fall from the side of the mountain of from 100 to 200 tons had lately taken place. The mass which came away consisted of a similar breccia to that already mentioned. It lay right in the bed of the stream, ready to be acted on, and carried away by the flood-waters in the winter months.

In this slab from Hartfell you will find about 30 Retiolite forms, which I have not yet identified. I believe they are the first of the species got in the locality. This other Retiolite I brought before the Society last year. The frond is lancet-shaped in form, 1-4th of an inch broad, and from 3 to 4 inches long, having a delicate central axis, with about 20 to 22 cells per inch. It is covered with a beautiful ringed network, which had, probably, at one time some protective covering. The cells are slightly alternate, and inclined at an angle of about 40°. Mr. Lapworth, of St. Andrews, to whom I sent this form for examination, has named it *Retiolites Daironi* (Lapworth).*

Here are examples of several branching forms of graptolites from the lower shales of Hartfell, many of them being extremely complicated in form. Little has as yet been done in the investigation of this class of graptolites in the Moffat shales—their ravelled and confused appearance being well calculated to deter any one from attempting to work out their original forms. Patience and perseverance may, however, yet reward us with perfect specimens, and we shall then be able to arrive at the true appearance of these interesting organisms. Doubtless they were beautiful objects, with their outspread branches floating around them; and only when they fell to the sea-bottom and died would their filaments assume the twisted and complicated appearance they now possess.

I may mention that in the Lower Llandeilo series of Wales and their equivalents of Skiddaw and Point Lévis, Quebec, the branching forms are obtained in a perfect state, which shows their original forms to have been quite different in character from those of the Upper Llandeilo of the south of Scotland.

* Prof. Lapworth, now of the Mason College of Science, Birmingham, has described and figured this species in the *Proc. Belfast Nat. Field Club, 1876-7*, p. 136, pl. VI., fig. 30.

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XXII.—Professor DAVID PAGE, F.G.S., *and his* WORK *as a* GEOLOGICAL WRITER. By E. A. WÜNSCH, F.G.S.

[Read 11th April, 1879.]

IN undertaking to bring forward this motion* I am not only prompted by my personal feelings, but by the knowledge that I shall be sustained by the sympathy of all the Members of the Society while I add a few words giving a slight sketch of Dr. Page's connection with us in our earlier days, as also while I endeavour to assign to him his true share in the progress and diffusion of geological knowledge in this country during the last 25 years.

I need not remind you that our Society, founded in 1858, has just attained its majority, and that the contrast between its present position and that of 21 years ago is almost as great as the contrast between infancy and manhood.

Only a few survivors now remain of the small band which two decades ago met one winter's evening, and timidly ventured upon the experiment of founding a Geological Society in Glasgow. At that time a man openly professing geology, with all the consequences then supposed to flow from its bold inquiries, required a great deal more of moral courage than he is called upon to display in the present day, when a knowledge, more or less extended, of its principles is considered a legitimate portion of a liberal education. Accordingly, small was the number of members and little was the progress made during the first few years, and it was not until we had the good fortune to secure Mr. Page's services for a first course of lectures that our Society, and with it the cause of geology, prospered and made progress in the West of Scotland.

From that date forward, year after year, a course of lectures by Mr. Page was the central point in the sessional programme of the

* "That the Office-bearers and Members of this Society record their deep sense of the loss to science sustained by the death of their Honorary Member, Dr. Page, whose memory is cherished by them as closely connected with the earlier history of the Society—as an active promoter of its interests by means of his admirable lectures, and as one to whom all Members of the Society and all Students of Geology generally must ever remain deeply indebted for his unwearied teachings and his able exposition of the principles of the science through his widely-known text-books and other writings."

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Society, and the subject as handled by the lecturer, the charm of style, the originality and wide scope of his views, and his power of reproducing abstract science in popular language and in investing it with a living interest, roused the attention and enlisted the sympathies of all classes of the community as much as, or more than, "Science Lectures" have done in more recent days.

At every successive course of lectures in the Merchants' Hall, then in Hutcheson Street—at that time the principal hall in the city for such gatherings—there was an increase in the attendance of the *élite* of the intellect of Glasgow, while with it came an increase to the popularity of the Society and a corresponding addition to the membership.

As an instance of their high character and originality, I may mention that the introductory lecture of one season, expressly written for our Society, was entitled the "Philosophy of Geology," and was afterwards expanded into a small volume, which was published under the same title. A copy of this work, dated 1863, which I now hold in my hand, I have read and re-read with great pleasure at various times, and have often in the author's lifetime quoted it to friends as the perfection of a clear scientific style and of philosophic reasoning. And now, when the active hand and busy brain which gave it to the world are at rest for ever, and sixteeen years, with all their new discoveries and views have passed over so progressive and so changeful a science as geology, this work is still as fresh as if written but yesterday—it is still crowded with passages as true and as suggestive now as on the day they were written—it sparkles, as it were, with prophetic insight; while almost every page affords room for quotations that will form the text for many an enlarged theme by future writers on geology.

This book is, however, only one of many similar publications. Text-books and handbooks of various kinds poured forth in rapid succession while the author was at the height of his mental activity—numerous editions succeeded each other, and translations of the leading works into various foreign languages appeared. To enumerate the different issues in detail to you would be superfluous, since they are "familiar as household words" to every student of geology.

And when the time came for Dr. Page's removal from Edinburgh to that honourable post at the Durham University, which he held to the close of his career—when his Glasgow friends began

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to fear that the greater distance which separated them, the more pressing calls upon his time, and also the increased physical suffering, which had already then began to show itself, might prevent him coming to Glasgow as often as hitherto—they invited him to a farewell entertainment, which will be fresh in the recollection of all but the younger members of the Society. On that occasion he must have been fully convinced of the high personal esteem in which he was held by his Glasgow friends, and I believe this was also the last occasion on which most of us beheld him.

Of his teachings in his new sphere we received the most gratifying reports, and, doubtless, there will be some who can speak of this from their personal experience. But, though bodily absent from us, his teaching remained—the good seed had been sown and had prospered—for the Society, as the older members will remember, had for a number of years made it an essential feature that in each session there should be a course of "elementary lectures," delivered by its own members and office-bearers, and founded upon Dr. Page's text-books. The burden of these labours was, as is well known, borne by our friend Mr. John Young, and so well did he acquit himself, that the system took shape in a regular and more extended course of lectures upon geology at the Glasgow Mechanics' Institution; and this course is, I am glad to say, still carried on by him there, and proves a valuable ally and feeder to our Society, under whose auspices it first took shape.

Had time permitted, it would have been a labour of love to me to enumerate more in detail the successive and varied aspects of the literary labours of our lamented friend. There is no doubt that this task remains to be done, and will be carried out at some future time by a hand more competent than mine; but I may, perhaps, in conclusion, adduce a single instance of the wide range of Dr. Page's writings in geological science, and of what may be called their suggestiveness. I have already referred to the highly-philosophic character of one of his works, and I now take up another volume of his writings, but one of an entirely different character from the last—one intensely practical. It is entitled "Economic Geology," and contains a wonderful amount of thoroughly work-a-day information, arranged so lucidly that a French writer and geologist, Dr. S. Meunier, has translated it, not in the usual sense of a literal translation, but, following the subject and enumeration of the author, he has in the same order

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reproduced the headings of the various chapters; and, giving the substance of the English text, he has added an account of the corresponding localities in France where the same substances are found, and of the corresponding processes by which they are made available to agriculturists, chemists, and all other industries. This little French volume I have also before me, and, though I never had an opportunity of learning Dr. Page's personal opinion of it, for it only appeared in 1877, I think it must have been felt by him as the highest compliment which one author could pay to another.

We therefore find a comfort in our sorrow in thinking that the good work initiated by a single master mind continues to increase and prosper. As geologists we are all conscious that our own minds are more or less pervaded by the teaching of the master who has departed from amongst us—"that though he be dead he yet speaketh"—and that his memory lives, and will continue to live, in the affection and gratitude of all true geologists.

XXIII.—*On the occurrence of* Flint Nodules *and* Worked Flints *in the* Post-tertiary Sands *of the* Ayrshire Coast *between* Saltcoats *and* Troon. By John Smith, Corresponding Member. With a Section [Plate VI.].

[Read 10th April, 1879.]

In the autumn of 1871 I first examined the sands of this portion of the Ayrshire coast, in the hope of finding meteoric stones, my reasons being that if meteors had at any time fallen it might be possible to pick up a few, as the sand was being constantly shifted by the wind, which covered up one part while laying another bare. After crossing some considerable knolls of blown sand, to my delight I came upon various patches of gravel lying in the hollows from which the sand had been blown. This was so much of what I had anticipated, that the search for the meteorites continued.

I found the gravel to be made up of representatives of almost every kind of rock, granites, contorted schists, clay-slates, a great variety of trap rocks, quartzites, conglomerates, sandstones, limestones, &c., with here and there small nodules of jasper. The granites and the harder varieties of rock were polished more or less

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by the continuous action of the blown sand for long periods of time. The traps and conglomerates had their softer components weathered out to a small extent, sometimes in a very fantastic way, and had taken on the general polish in a greater or less degree. The limestones, when pure, presented the appearance often seen in old walls built of that material; those that were foul being covered with a rusty crust of silica and alumina, and being in some cases rotted to the centre. No meteorites fell to my lot; the heavens had been unkind, but the earth was more generous. Instead of meteorites I got a few flints, several of which had evidently been worked by the hand of man into rude implements; some were simply chips, and others regular flint nodules which had never been broken.

I think there is no place in the country where one feels more shut out from the world than when ensconced in one of these gravel-covered hollows. Nothing is to be seen but sky, and hills of blown sand, rising to the height of 30 or 40 feet, bounding the view on every side. Some of these are covered with bent, while many of them are bare, and it takes no great stretch of the mind to imagine you are in the heart of some great wilderness. I have often thought that a painter would get as good surroundings here for a desert scene as he could find in the sandy wastes of Arabia.

On the wall I have placed a sectional diagram to illustrate the Post-tertiary sands and clays of the Ayrshire coast (Plate VI.). At the bottom of this section is the Boulder Clay, in some parts 67 feet thick, its top being at some places 44 feet below high-water mark, and it appears to deepen and thicken seawards. So far as I have seen, there are no flints in the Boulder Clay. Above this occurs 2 feet of reddish clay, very finely laminated, and containing a few foraminifera. On top of this is a laminated sandy clay, from which Mr. D. Robertson has registered 157 species of Post-tertiary fossils. Above this is 77 feet of stratified sand, at some places 44 feet being below high-water mark, and fossiliferous in some localities to about 14 feet above sea-level. It must, however, I think, have at one time contained fossils throughout its entire thickness, but these have been entirely rotted away by the percolation of water holding carbonic acid in solution. In some parts of the sand many of the fossils and pebbles are in the last stage of decay, and in a few more years they will have disappeared, leaving no trace behind. This sand

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exhibits many local peculiarities. At Misk the lower part of it is interstratified with thin layers of vegetable mud. In Eglinton Castle policies, at a depth of 7 feet from the surface, and 13 feet above sea-level, occurs a bed of peat, 12 to 18 inches thick; and at Bogside, at a height of 32 feet above sea-level, are 2 or 3 feet of rather coarse gravel. Patches of gravel are frequent in the upper half of the section, and false bedding is common. In this sand, at 24 feet below sea-level, and from that to the top of the Boulder Clay, striated boulders, some of them half a ton in weight, are not uncommon, and have evidently been brought into their present positions by ice. I have got flint nodules as far down as 24 feet below sea-level. Throughout the section of stratified sand above sea-level, nodules of flint are to be found, although they are by no means common. In no part of the stratified sand have I detected a worked flint of any kind, all those I have got from it being rolled nodules.

On the top of the stratified sand occurs an ancient soil, in some parts covered by 30 to 40 feet of blown sand. Lots of flints occur on the top of the soil, all being either worked flints or chips—no nodules, so far as I have seen, being present. I have never found flints of any kind in the blown sand, except the smallest chips, which are in some places very common, and have evidently been blown up by the wind. Flints both worked and in nodules are not uncommon in the hollows amongst the gravel, and on the slope marked A in the diagram. It appears to me that when the people who used these flint implements lived in this district there was no blown sand along the Ayrshire coast; that a rich soil, outliers of which are still to be seen, extended down to the then sea-shore; and that the land stood, perhaps, 5 or 6 feet lower than it now does. All along the coast for a distance of 500 yards inland no worked flints are to be found, and this is the reason why I think the land stood lower when the ancient people lived here who worked and used these flints. In the hollows of this belt, the usual gravel, interspersed with flint nodules, is found; but there is not the vestige of a worked flint, so far as I have observed. Had this part not been covered by the sea at that time, it is odd that no worked flints should be found in it, when so many are got in close proximity. Here, however, a very beautiful polished celt turned up. It belongs to a type I have never seen figured anywhere, being curved near the butt in the

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plane of the cutting edge, and the butt ending in a point. I think it is generally admitted that polished celts are by no means so ancient as chipped flints are; and I may add that among all the flints I have found in the sands of the Ayrshire coast, there is not one which has been ground and polished. I believe the reason why the worked flints are got in the hollows, is that they have been let down from their original position on the ancient soil. The soil and the flint implements have first been covered with blown sand from the shore. When this sand was shifted further over by the wind, the soil, with 12 to 15 feet of the stratified sand below it, was also shifted inland by the same agent, the prevailing winds being from the S.W. The worked flints in the soil, and the gravel and flint nodules in the stratified sand, were let down as the sand was blown from about them; hence their position in the hollows. The process of letting down is well seen on the slope marked A on the section. After rain the gravel and flints are found on little pillars of sand ½ an inch to 1 inch high; when these pillars dry, the wind is not long in undermining them, and the flints and gravel are thus gradually lowered. When this has gone on until the level has been lowered from 12 to 14 feet, the gravel is found to cover the sand almost completely, the sand beneath becomes protected by it, and the lowering process ceases. I said that small chips of flint were found on and in the blown sand, and I now exhibit a quantity of these fragments. They are evidently small chips which have been broken off in preparing the worked flints. Of course, many of the chips are also found in the gravel hollows. You will see they are all polished by the action of the moving sand, as all the worked flints are also similarly affected, and this gives them quite a different appearance from flint which has been recently broken.

I will now give a short description of the flint implements and weapons which I have found in the gravel-covered hollows, on the slopes between the hollows and the ancient soil, and on the ancient soil itself. Up to date, I have got 1,150 regularly worked flints, and several hundreds of flakes which appear to have been used, although there is no secondary chipping on them. The most common kind of worked flints are scraping knives, which were used for preparing skins, making bows and arrow-shafts, and for other purposes. These knives may be roughly divided into seven classes—straight-edged, lance-shaped, duck-bill-shaped, semi-circuloid, patelloid, spokeshave-shaped, and irregular flakes, with

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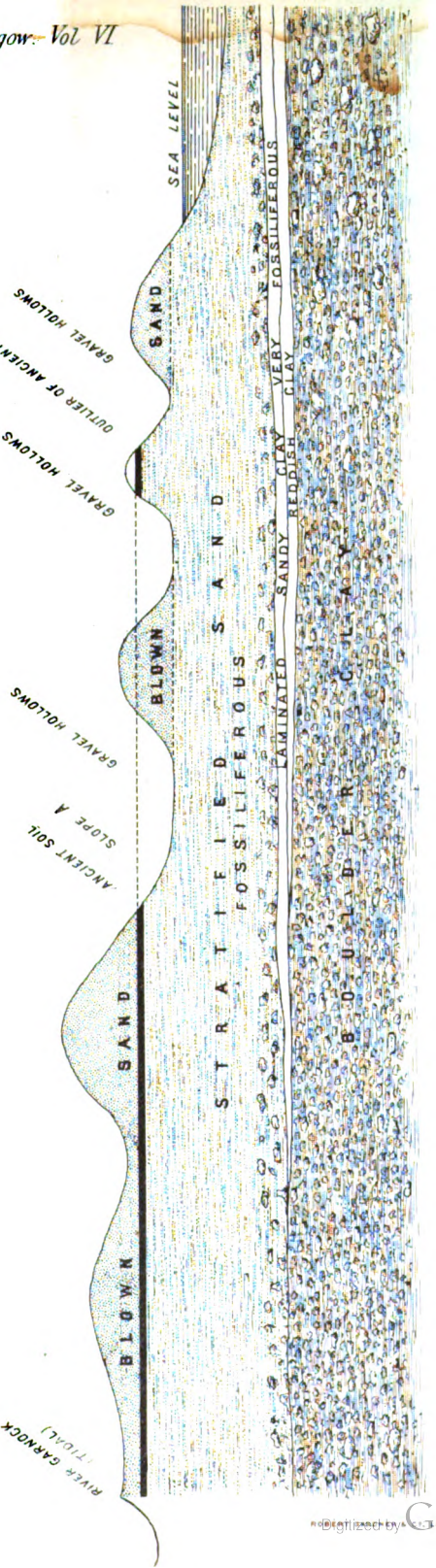

SECTION TO ILLUSTRATE J. SMITH'S PAPER ON THE AYRSHIRE COAST FLINTS.

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concave chipped hollows, which have evidently been used for finishing arrow-shafts. All these knives have been fashioned from one side. The limpet-shaped ones have a somewhat elliptic base, their peculiar appearance being due to the flakes from which they were made having been worked all round, the oblique chipping having met in a point at the back. Some of the spokeshave ones are serrated on the edges. Two of the knives are made of small pebbles of striped jasper, and two are of green jasper. Here are drills used for boring holes in bone, horn, wood, or even stone. The smallest bores a hole ½ an inch in diameter; the largest, which is made of green jasper, nearly 1¼ inch. In this piece of slate I bored a hole with one of the flint drills, and a very good hole it has made. They are fashioned in the same manner as the engineer of the present day makes his drills. When a hole has to be bored they must be turned in the same direction as the hands of a watch move—*i.e.*, from right to left—with the exception of two, which have to be turned from left to right, and appear to have been used by a left-handed man. If they were ever used as arrow-heads they would set the arrow spinning in the air, like a ball shot from a rifle. The ancient implement-makers have taken advantage of the fact that flint always breaks with a conchoidal fracture to give a fine edge to their tools. Many of the flakes are worked on the convex side, which, as you will see, gives a much sharper and finer edge than when they are made in any other way.

In the making of these ancient tools the flint workers have shown a considerable amount of skill, and in some of the more delicate ones not a little art. Some, from the delicacy of the workmanship put on them, appear to have been used as surgical instruments, and perhaps for the purpose of tatooing. The others are all arrow-heads, some of them being beautifully made. They are of four types. One has the usual sharp point with straight sides, and a convex base where it fitted on to the shaft. The next type is similar in shape to the first, only having a central prong where it was fastened to the shaft. The next type is similar to the second, but instead of the sides being straight they are convex. The arrow-heads of this type are all very small, and, from the breadth of the base in proportion to the length, appear to have been made from larger implements of the second type, whose points had been broken in use. These three types of arrow-heads have all been worked from both sides. The arrow-heads of

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the fourth type are all leaf-shaped, one of the best being made of quartzite.

All the arrow-heads are of small size as compared with those from other districts, and the same may be remarked of the worked flints—which leads one to believe that the flints from which they were made were found in the neighbourhood. Had the flints, from which these implements were made, been brought *by man* from the coast of Ireland, large pieces would have been brought as readily as small ones. The largest worked flint I have is 2¼ inches in length, and I have already picked up as many nodules as would make all the worked flints that have been found. If the flints in the stratified sands are the remnants of a lost Chalk formation in this part of Ayrshire, as I once considered them to be, we ought to find large nodules of flint as well as small ones. The largest nodule I have got below sea level is 15 ounces in weight, and the largest one I have seen above sea level, in the stratified sand, weighs 2½ ounces, and the largest I have from the gravel-covered hollows is 9⅛ ounces. Had the flint nodules been brought from Ireland by ice we ought to have large nodules as well as small ones. At present I am inclined to think that these flint nodules were at one time brought from the coast of Antrim by sea-weeds; and the reason why the size of the flint nodules in the stratified sand never exceeds a certain bulk, is, that the carrying capacity of a sea-weed is limited. One circumstance seems to favour the idea that they were brought from the north of Ireland, and that is the occurrence of reddish flint, such as is to be got at the junction of the trap with the chalk in Antrim. At the present time a small patch of gravel is being formed near the mouth of the river Garnock by the action of sea-weeds. Every time the tide comes in it brings a lot of sea-weed with it, and almost every weed has got fastened to it a small pebble. Many of these are carried out by the receding tide, some of the heavier ones being trailed along the bottom, leaving long furrows in the muddy sand. But many are left, and, when the sea-weeds rot, they augment this gradually-increasing deposit of gravel. Flint nodules are found in this patch of gravel, but whether brought from some of the neighbouring ports, where plenty of flint always occurs in the old ballast, or from some other place, it would be hard to say.

Quartzite, which is a very hard and tough stone, has been the material which the ancient implement-makers have used as anvils

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when striking flakes from the flint nodules, and these quartzite anvils still preserve the marks of usage they have been subjected to. The pieces of flint I now exhibit are evidently cores from which flakes have been struck.

Mixed up with the flints are fragments of pottery and bones, in the last stages of decay. These are found in the ancient soil, and in the gravel-covered hollows—never in the stratified sand, so far as I have observed. The flint implement-makers seem to have been hard up for materials to make their wares from. Here are a number of scraping knives made from small split nodules of flint. A number of them have evidently been burned, which, perhaps, suggests funeral rites and cremation.

Although it appears that the flints in the Post-tertiary sands of the Ayrshire coast are of Irish origin, yet I believe that the Chalk formation extended at one time over a considerable portion of the low-lying parts of Scotland. Mr. David Robertson, in his paper on the Post-tertiary Deposit of Misk Pit, near Kilwinning,* takes notice of flints having been found at Loch Lomond, Kirkcaldy, Belhelvie, Portobello, Leith, Elie, Montrose, Island of Stroma, John o' Groat's, Peterhead, Fyvie, Turriff, and in the so-called Boulder Clay of Caithness.

In this part of Ayrshire the direction of the glacial striæ point to a S.S.W. movement of the ice. Any patches of the Chalk which had escaped previous denudation would almost surely be carried seawards during the glacial period, and this may account for the absence of flints in the Boulder Clay of this locality.

[*Note*—Nov. 1881.—Since I read the above paper I have found a good flint scraper in a ditch which was being cut on the farm of Nethermains. It was got at the depth of 5 feet from the surface, in *stratified sand and gravel*, which appears to have been deposited by the River Garnock, and at a spot about 100 yards from the present bed of the river. Numerous flint nodules were also got in the same section, and several broken flint flakes.]

* See *Trans.*, vol. v., part ii., page 297.

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XXIV.—A Visit *to the* Eifel *and its* Volcanic Rocks. By James C. Christie.

[Read 10th April, 1879.]

About the middle of last July I started from Leith, with the intention of proceeding by way of the Rhine to Switzerland, my object being to lay in a new store of health, and to examine a series of Miocene beds, near Oeningen, a village on the northern shore of the Boden See or Lake of Constance, which have been most minutely and carefully examined and described by Professor Heer of Zurich. Taking his book with me as a guide to the locality, I continued to study it while journeying slowly and pleasantly southwards by a Rhine steamer, which I left at Cologne, to have another look at the famous cathedral, and to examine the geological collection in the museum there. There was, however, none, as the museum, though containing lots of stones, had nothing for the geologist, but much for the antiquarian. Sauntering into the cathedral, I began to examine the stone of which the pillars of the imposing edifice are built, and soon found myself at sea, for it seemed to be entirely different from any found in this country—a fact which, though often in the building before, I had never noticed, no doubt because my attention had not been directed to geology. Certain long markings on the stones seemed, at first sight, to resemble sections of encrinite stems, and I was strengthened in this idea by the castellan of the cathedral, who informed me it was constructed of limestone, though he could not tell from what locality it had come.

Specimens taken from the same locality* as that from which

* The Drachenfels, one of the heights of the Siebengebirge at Königswinter, whose "castled crag frowns o'er the wide and winding Rhine." On visiting this district some days later I at once recognised this rock as that of which the pillars in the Cologne Cathedral were built, and I learned that it had been quarried in ancient times for building purposes, but that it is not now so used, as it weathers badly. It is a trachyte, and contains very large crystals of sanidine-felspar, which seen in section look very like encrinite stems. This rock does not occur in Britain nor elsewhere in Europe, so far as I am aware, but specimens are to be seen in all good museums, and are easily recognisable.

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the building-stone of the cathedral was obtained lie on the table, and I hope to be excused for having blundered so egregiously as to mistake a volcanic rock for a limestone. The cathedral pillars and walls had a thin coating of whitewash, and were besides pretty much soiled by finger-marks, and any attempt to make a fresh fracture, even in the interests of our noble science, would probably have led to my transference to the interior of a German prison. Resuming my journey on the Rhine, I took up Baedeker's Guide to Northern Germany, and observed a note, in very small type, which stated that a very fine collection of volcanic rocks from the Eifel district was to be seen in the museum of Bonn. As we were close to that town, I hurriedly gathered myself and my "traps" together, and landed, securing accommodation near the pier, in the "Stadt Bonn," whose landlord, Herr Müller, deserves my best thanks for the great care he bestowed upon the bags of specimens which I forwarded to him occasionally, as I moved from place to place. Taking the shortest way I hurried off to the museum, and had no reason to be disappointed, for the collection is really a splendid one, and worthy of the university to which it belongs. Quitting it about 8 p.m.—for visitors are permitted to stay during daylight—I returned on the following morning, and began to study a map of the Eifel which was on the wall. Seeing a gentleman removing specimens from the cases, I put a question regarding the district, which he very politely answered, and meeting him in the university avenue in the evening, he inquired whether it was I who had spoken to him in the museum. He said he was Professor of Mineralogy, and that he intended starting at 6.40 next morning, with a number of his students, to the locality about which I had been inquiring, and he very kindly asked whether I would like to join the party, and I replied that I was only too glad to have such an opportunity. Rejoicing in my good fortune, I repaired in due time to the station, where I found a number of young men, who were provided with "pokes" and hammers, and, producing mine as my introduction and credentials, I soon fraternised with them. Time for the train to start, but still no word of the professor, and the station-master even caused the guard to delay the train, till at last he appeared, breathless. This incident led me to suspect that he was a man of some importance, and this proved correct, for in addition to being a man of considerable wealth, Professor Vom Rath has a reputation as a mineralogist which is

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not confined to his native country. We proceeded up the left or western bank of the Rhine for nearly 40 miles, and then, by a branch line westward, to Niedermendig, where we entered the renowned volcanic region called the Eifel. On the way our guide had drawn our attention to certain outbursts of basalt which could be seen protruding from the cliffs dominating the Rhine; but here we found ourselves amongst the true lavas. On our way upwards to the higher grounds Vom Rath took us to a quarry by the roadside near the village, where there was a fine vertical section of volcanic ashes and cinders to a considerable depth, the ashes being used for road metal. Many such quarries are to be found all throughout this district, but, as this one was the first I saw, I expended on it a large share of my enthusiasm — it was so entirely different from any volcanic ash that I had ever seen at home. It consisted of ashes so loosely coherent that any quantity of it could be detached from the mass by simply digging into it with a stick, and the lines of stratification were clearly discernible by difference of size and colour of the lapilli. They varied in size from that of a bean to that of a hen's egg, the average being about the size of a cherry, and in colour from a deep black to a dirty grey, the latter being where there was a large admixture of fragments of pumice-stone. The professor explained to us that it was a shower of similar cinders that had entombed Pompeii, describing his own experiences in the still active region of Vesuvius; and I had never so thoroughly realized the nature of that awful catastrophe as when standing in this very quarry. On the ridge above we came upon a deposit of an entirely different character, consisting of huge blocks of hard basaltic lava, scattered about or lying close together, and of irregular shapes, many of them measuring several feet in diameter. The hardness of the rock prevented us from obtaining specimens readily, and while absorbed in this work our guide went down the hill, leaving his assistant and four or five others, including myself, to follow. When we had finished, the professor and the main body of the party were out of sight, and his assistant took us up the slope of another higher ridge, past the fruit trees, and through the fields, of the peasants of the village. It soon became evident that we had lost our guide and our party, for no amount of calling produced any response, while to my horror I discovered that our conductor had never been in the district before, and hardly even understood the map.

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After about an hour's wandering, in which I had assumed the leadership, being eldest of the party, we found a carter, who had seen the professor and his followers pass, making for a neighbouring crater called the Bellerberg; and soon we could see them toiling up the side of the cone and then passing over the ridge, but being rather fatigued with our hunt and the heat of the day, we did not make the ascent. On their descent we joined them and heard their description of the crater. It is beautifully marked with concentric ridges, narrowing as they near the centre, and resembling the tiers of seats in the gallery of a circus, and I have observed similar characteristics in many of the other craters which I afterwards visited. We then rested for a short time in a village inn at mid-day where we had some lunch.

Resuming our journey, and going very gently down hill, and passing signs of volcanic agency everywhere on our route, we reached the Laacher See, which lies in a hollow surrounded by volcanic cones, whose upheaval has caused the formation of this lake in the centre of them. Unlike the others in this region, it does not occupy the site of any extinct crater, but is surrounded by them on nearly every side. It is oval in shape, about $1\frac{3}{8}$ mile long by $\frac{7}{8}$ mile broad, and 165 feet in depth. The abbey of Laach stands on its bank, surrounded by a few houses, amongst them being a most commodious hotel, which is much resorted to by excursionists, anglers, and bathers, and, last but not least, by geologists from all parts of the world. The waters of the lake having been regularly increasing, the owners of the abbey had to excavate a tunnel to tap the lake, and so save the abbey and its lands, and in this engineering feat they were quite successful. Most of our party dined in the hotel, while a few of us bathed; and then, leaving the lake, we passed upwards along a gentle slope and descended into a valley, where our professor conducted us to the first of a series of mineral springs, which abound here and in one or two other valleys which debouch on the Rhine. The famous Apollinaris Water is obtained from a spring in the Ahr valley, not far distant from that of the Brohl, at the head of which we now were. The waters of these springs are delightfully cool, and very highly impregnated with carbonic acid gas, to such an extent, in some cases, that the water gushes up from the ground as if it were boiling violently. It has a pleasant sourish taste (it is called by the Germans Sauer-wasser), and almost

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any quantity of it may be drunk with impunity. The day being far spent, we went by forced marches, on learning how far away from the Rhine railway we still were, and the party having to go home to Bonn the same evening. As it was immaterial to me where I lodged, I bade them good-bye at the village of Brohl, where I decided to remain till Monday, as I wished to examine the valley leisurely, it being one of extraordinary geological interest.

The valley is about 6 miles long from Burg Brohl to the Rhine. Here and there are found, filling up its hollows to a depth of from 60 to 100 feet, vast remnants of a most valuable deposit, which, there is every reason for believing, occupied at one time the entire valley. This deposit, which is known as "Tuff," has long been dug and quarried out by the natives, who grind it down in mills driven by water power, pack it, and export it to Holland and other places, where it is used to produce a cement, which has the valuable property of setting under water.

As it completely fills up all the irregularities in the sides of the valley, it has evidently been deposited after the valley has been scooped out by the present small river. And the stream has again cut through the "Tuff," leaving it most abundant in the wider parts of the valley, especially within numerous curves which are found in it.

This curious volcanic product is of a uniform composition at given depths, the lower stratum being so different from the upper that it is of little commercial value. Sir Charles Lyell, who has visited the locality, states that it is unstratified; but I am inclined to think, for the above reason, that he is mistaken as to this.* It is certainly not quite homogeneous, although its composition varies only in degree and not in kind. There are no distinct lines of demarcation separating it into beds, as is the case with ordinary

* The lower deposit or layer had possibly not been reached in any of the workings when Sir Charles Lyell visited them, or at least in those which he saw. In July, 1879, I took the opportunity of consulting His Excellency Dr. Heinrich von Dechen, whom I had the good fortune to meet in the house of Professor Vom Rath, and from whom, when he learned that I came from Scotland, I received a kindly reception such as I shall never forget. He had visited this country in 1822 to study its geology, and that of Fingal's Cave in particular. He was Director of the Geological Survey of Germany. He informed me that the deposit in question is a stratified one, consisting of two layers, the upper one being finer in quality and of greater depth than the under one.

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stratified rocks, but the various qualities of the "Tuff" blend gradually into one another. It is of a light brown colour, speckled with numerous white spots, which consist of small rounded fragments of pumice-stone, some of which are of considerable size.

It is said by Sir Charles Lyell to contain pieces of burnt shale, slate, and sandstone, also trunks and branches of trees. I could discover in it none of the former, but the branches of trees were tolerably abundant, most of them burnt almost to a cinder, and wonderfully preserved in their air-tight and water-tight matrix. In some other cases I found branches of trees with the wood so sound that it could with difficulty be cut, and with the bark adhering firmly to it. Specimens containing very clear impressions of delicate leaves are occasionally but rarely found. This seems to indicate that the flow at different places was not of uniform heat, but whether the different degrees of burning, to which the plant remains were subjected, correspond to varied depths in the deposit, is a point which I did not succeed in determining, as I found only the carbonized wood *in situ*, the rest, including the leaves, being got in quarried blocks, which were piled up in heaps for the mills.

I am sure, however, that these various organic remains were embedded under very different conditions from those discovered by Mr. Wünsch in Arran (*Trans.*, vol. ii., page 97), and upon the subject I have formed the following theory, which I submit for your consideration.

There is abundant evidence that this deposit flowed into the valley after its formation by the denuding force of the Brohl stream. Suppose that a very active period in the history of the neighbouring craters took place, and that an enormous mass of fine volcanic ashes—principally pumice-stone—was borne by the wind, and deposited at the upper end of the valley, and necessarily damming back the stream. A lake would then be formed, and would grow until the accumulating pressure of the water would overcome its barriers, and a torrent would sweep downwards, bearing along a mingled *débris* of ashes, mud, and fragments of the highly contorted but somewhat soft slaty rocks which crop out along its sides.

In the principal mass of the Tuffstein Vom Rath says the fragments of slate are very rare and very small. Their presence may also be accounted for by supposing them to be the fragments of the grauwacké slate, which would be torn up when the volcanic

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masses were forced through them from below. I would account for the charred branches by supposing them to have belonged to trees which were enveloped in the showers of ashes, the heat being sufficient to char the wood, while the leaves and sound wood may have been borne down and enclosed in the liquid mass deposited by the water, which would form a thoroughly air-tight case sufficient to preserve the wood and leaves in the perfect state we now see them. My only difficulty as to this theory is the great amount of the Tuffstein deposit.

Vom Rath says it is not in an exact sense stratified, and in this he agrees with Lyell, but he says that it consists of two distinct flows, which can be distinguished from each other by difference in colour. Sometimes the under layer is thick, and in that case the upper is comparatively thin; but the reverse is often the case, so that the mass has often the appearance of false bedding.

At the very head of this valley stands one of those ruined castles which are so numerous in Germany, relics of an age which is much more recent than that we have just been describing. It is built on a small hill which has been formed by an outburst of a rock, which I took to be phonolite, as it agreed with the description given by Rutley, but which Vom Rath informs me belongs rather to the class of leucite-noseans, which are found abundantly in the vicinity of the Laacher See.

Between Burg-Brohl and Schloss Olbrück, and dominating the road which connects the two places, rises a very remarkable crater called the Bausenberg, which I shall attempt to describe to you. It rises to a considerable height, 480 feet above Nieder-Zissen, to the N. of the village, but only about three-fourths of the crater remain, the other portion having been destroyed during an eruption. I approached it at a part where the cone is complete, and having had a long day's walking before reaching it, I struggled with some difficulty through the trees and thick brushwood with which its sides are clothed. They seemed to thrive well, though the soil upon which they grew was entirely composed of volcanic ash, while, wherever an open space appeared, there was a tolerably luxuriant sward of grass.

Descending on the inner side, I emerged at length from the trees, and found I was in the bottom of the crater, and that here was a level part divided into two fields, which were cultivated by a family residing in a comfortable-looking two-storey house which

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stood right before me, their entrance being by the break in the side. At a point on the side of the crater, 71 feet high, where some enormous blocks of lava enabled one to get a splendid view of the surrounding country, I saw the far distant hills on the right bank of the Rhine, and a considerable part of the Eifel district, which I had trudged over two days before under Vom Rath.

On my descent I discovered that a tolerable roadway wound round the cone for the convenience of its inhabitants, who in several places have made openings in its surface in order to supply themselves with road metal, which they find in an exceedingly convenient form, as they have simply to separate the larger bombs and use those of suitable size for laying upon the road. Here the prevailing colour is a rich deep blue, and some of the fragments from their shape show that they belonged to parts of the stream which had been drawn out into the ropy form when in a viscid condition. The specimen on the table will be sufficient evidence of this.

In another cone in the immediate neighbourhood, called the Herchenberg, there is a very peculiar arch to be seen, formed in a portion of the lava, which projects to some little distance inwards from the wall of the crater. It is about 8 or 10 feet high, and is evidently entirely natural. This cone differs from the Bausenberg, which has but one central and symmetrically-formed opening, in having several distinct vents on its sides, forming irregularly-shaped craters, with walls formed of huge amorphous blocks of lava, embedded in great quantities of volcanic ash. On the sides of one of those openings there is a remarkably fine section, displaying a number of clearly distinct beds of ash, which differ from each other in the colour and size of the lapilli, rendering the stratification very distinct, and showing that this deposit had taken place at different periods of time.

Having confided my specimens to the care of a carter who was taking a load of the Tuffstein down to the Rhine, I trudged after him, and boarding the steamer in a ferry-boat, got hauled on board, with my pokes, reaching Bonn in an hour or two. I remained there for three days, spending most of my time in the splendid museum. I then went to Gerolstein, a small town with a mineral spring of some repute, about 50 miles S.W. from Bonn, and walking about two miles further to Pelm, I found a grand section in a railway cutting through the limestone within a few

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yards of the door. This limestone, or "Eifelkalk," which, according to Lyell, is the great central and typical member of the Devonian on the Continent, is not very pure, and several bands of it are so shaly and soft that one's fingers are almost sufficient to disengage the corals, which are to be found in great quantities, ranging in size from an enormous diameter down to those of the utmost minuteness. I could not help wishing that our friend, Mr. J. Thomson, had been there to see their extraordinary abundance, and to discover a new species, if that be possible for him at this time of day.

The village of Pelm is on a small river, the Kyll, which first passes through Gerolstein, and ultimately falls into the Mosel, below Trier. It seems to have excavated its valley in this limestone, for on its left bank there is a magnificent line of finely-weathered lofty cliffs frowning grandly above it. On the plateau above there is a fine crater called the "Pappenkaul," to which, after a considerable amount of wandering, I found my way. The crater is small, and is littered with great blocks of lava and large rounded bombs. The interior, however, being level, is tilled by the peasants, whom I found removing a crop of barley from it. This level centre, such as is to be seen in many of these craters, has doubtless been formed by the washing down of the finer ashes, which have weathered, in this particular cone, into a good red, though extremely dry, earth.

Having selected some specimens of the smaller bombs, I made my way down to the railway line, and, following it, reached the village again, where I found that the boys were accustomed to visits from fossil hunters, who buy specimens from them in the same manner as is done at home.

I should like to introduce two of the local collectors to you. The first and best known—Karl Michels—is a half-witted gardener (the son of a former schoolmaster, who was also a collector). Karl gets the credit in the village of being able to see four feet deeper into the ground than any other person, and various amusing anecdotes are told in illustration of this. The other is Johann, the village swineherd, who is in a certain sense an official. When out on the hills with his porcine charges, Johann looks about him, and deposits in an old stocking whatever fossils he may come across on the surface, where they are very numerous. The strata of shale crop out, and as the material is very soft, the fossils

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weather out in fine preservation. He introduced one to my notice as a special curiosity, which he pronounced to be "an owl's head." On expressing my incredulity—for I believed it to be a weathered and water-worn specimen of a trilobite—he pointed out its eyes, and declared that he was right, for there were owls, as he had seen them often, and they caught mice, and this he considered proof positive. Another specimen was produced from the stocking, and this, he said, was "Kuh-flap," and explained to be a coprolite of an antediluvian cow, but which I have since ascertained to be a species of coral,—*Cyathophyllum lamellosum.*

The railway station being only two miles distant, I was enabled to despatch from the place two heavy bags of specimens, weighing nearly two cwts., to Bonn, where, on my return, I found them safe under the charge of Herr Müller. I left this for Daun, where the surrounding district is of special interest to geologists, as it abounds in volcanic cones and lava streams. Six miles to the north there is a meadow called the Dreiser Weiher, where volcanic bombs (consisting entirely of crystals of olivine) are to be found scattered about, some of them measuring 1½ feet in diameter. About 1½ miles N. of Daun there is a long ridge of cliffs called the Dauner-Lei. Its front consists of immense blocks of lava, which have broken off from the main mass of the flow, and have then remained nearly in their original position, and without showing many signs of weathering, as their edges are not by any means rounded. What has led to such a rending of an unstratified and compact mass, I cannot say, unless from cracks being formed in the mass when cooling. An exactly similar formation of immense blocks is seen at the Horngraben, on the Kleine-Kyll. Daun is in the centre of a district of about 50 square miles, abounding in volcanic craters and lava streams. The principal cones in the neighbourhood are the Nerotherkopf, Hohenfels, Scharteberg, Errenberg, Felsberg, Waldkönigen, and Steinborn. At the latter I found a few men engaged quarrying the lava, which is formed into cattle troughs, door steps, door posts, lintels, oven floors, &c. The quarry exposes a fine section of four different strata—the lowest of porous basaltic lava, the second of a slaggy nature, the third a bed of volcanic sand and scoriæ, and the fourth and highest basaltic lava. In the scoriæ found in many of those quarries, small plates of mica are got among the ashes, in some cases adhering to them. Occasionally fragments of calcined shale or limestone of a

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brown colour were to be observed, showing unmistakable signs of having contained fossils, but if one attempts to separate them from the mass of cinders they crumble into dust in the fingers. Daun forms the northern apex of a triangular district, having its eastern base at Gillenfeld and its western at Bettenfeld. This district includes five small lakes ("Maars"), which occupy the craters of extinct volcanoes, and one other, the Holz Maar, which is not surrounded by any crater, but lies in level ground. The nearest to Daun of these crater lakes, or "Maars," lies just above the village of Gemund, and is hence called the "Gemündener Maar." In passing along the highway from Daun to Gemünd the geologist observes beautifully-exposed strata of sandstone and shale tilted up almost perpendicularly in many places. These beds belong to the Coblenz Schichten or Old Rhenish grauwacké of the Devonian. It is useless for building purposes, as it splits up and breaks with the greatest facility. Some, but very few, of these grauwacké beds contain fossils. Leaving the road, which runs along the river Lieser, and passing through the fields which occupy the lower slope, the ascent of the cone proper is commenced. The upper and steeper part is too steep for cultivation, but is wooded. Reaching the summit by its western side (which is without any trees), the Gemündener Maar is seen below in the centre of the crater. It is almost circular in shape. It is from twenty to thirty acres in extent, and is apparently of considerable depth, for the water-lilies and rushes, which are very abundant, are to be found growing only close to the sides. The soil consists of weathered volcanic ashes, but nowhere on its surface do I recollect having seen any precipices of sandstone or shale, as mentioned by Lyell, although I walked round the lake. It has no visible outlet for its waters, and no stream flows into it. It must be fed by the rain-fall which falls within the area of the crater. On the exterior western side of the cone is a quarry, in the shape of a tunnel, cut into a deposit of the finest volcanic ash that I saw in the Eifel. It is almost as fine as the finest emery powder, is of a black colour, and is used for mixing with building lime.

Leaving the Gemündener Maar, and passing eastwards to a long hill, consisting of volcanic sand, another crater is reached, which contains another similar lake, called the Weinfelder Maar, but of irregular shape, and occupying an area of about 45 acres. Its waters stand 245 feet higher than those of the Gemündener Maar,

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and it has neither visible outlet nor inlet. From the appearances of the margin, the water seems to be stationary, neither rising nor falling much. The Schalken Mehrener Maar is 50 acres in extent, and its waters stand at a level of 50 feet above the Gemündener.

The Alf, a tributary of the Mosel, flows from the south side of this lake, as a very small stream. Four miles south-east lies the finest and largest of these lakes, the Pulver Maar, near the village of Gillenfeld, which has been almost rebuilt since the disastrous fire in 1876, in which several of the inhabitants perished in their houses. The Pulver Maar is nearly circular in form, is 90 acres in extent, and 350 feet deep. The height of the inner sides of the crater, from the water, is comparatively little, considering its area, and the slope is gentle and finely wooded with forest trees. The lake abounds in perch, pike, and fresh-water crayfish, the latter of which are highly esteemed as a table delicacy. They are caught here in great numbers by torch light, packed in wicker baskets, and sent off to far distant places, even to France, and are kept alive by having a little water poured on the baskets occasionally. Five miles south-west of this "Maar" lies Manderscheid, on the Lieser, another tributary of the Mosel. To reach it from the east, the traveller must descend to the bed of the small river by a steep winding road, cut on the face of the cliffs, which have been formed by the denuding power of the stream. On the descent I observed the finest illustration of contorted strata that I have ever seen, not excepting those in the Munster Thal, in the Jura mountains, on the western border of Switzerland.

All along the banks the lofty cliffs exhibit the strata heaved up at all angles, often perpendicularly, and also afford a remarkable illustration of the denuding force of water. These cliffs are not the sides of a range of hills skirting the river, as may be easily seen from the summit of the Mosenberg, which lies to the S.W. From this elevated position the surface of the country is seen to be of a very uniform level, and glimpses of its windings can only occasionally be had where the stream lies directly in the line of vision. Everywhere else long sinuous hollows may be traced, winding over the surface, but the streams whose waters have scooped them out are invisible. One glance over this district, after having crossed the Lieser and the Kleine-Kyll, would be sufficient to convert the most stubborn sceptic as to the denuding power of rivers. The cañons of Colorado, as figured in Huxley's

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"Physiography," do not afford finer examples. The Mosenberg lies three miles west of Manderscheid, and is the most remarkable volcanic mountain in the Eifel. It has three peaks, the highest (1731 feet), and four craters, the walls of one of which rise to a height of 50 feet. The height of the cone above the grauwacké through which it has protruded is only about 255 feet. One of the craters, perhaps the finest in the Eifel, contains a small lake, and the surrounding walls are marked by a series of concentric ridges of lava, which narrow as they approach the centre. There is no vegetation on these rocks, and we might almost imagine the eruption had ceased only a few years ago. A stream of basaltic lava, three-quarters of a mile wide, may be traced from the Mosenberg to the Horngraben, where it has reached the valley of the Lieser, 3 miles distant, terminating in a steep slope, covered with large blocks which have fallen from the front of the lava stream.

The ends of those lava streams do not seem to terminate in perpendicular cliffs, the only exception to this being the cliffs called the Falkenlei, near Bertrich. In a stream of basalt at Bertrich a most interesting but short tunnel is to be seen, called by the hotel keepers in the village, the Elfen grotto, but by the common folks, the Käse Keller (or cheese cellar), from the cheese-like form assumed by the segments of the basaltic columns.*

The basalt has flowed into the small valley formed by a brawling stream which rushes past, and is proved to be more modern than the valley into which it has flowed.

A professional brother of my own, Herr Geffken, from Barmen, near Dusseldorf, whose acquaintance I made accidentally, very kindly took me over the ground near Bertrich, when he learnt that I had come expressly to see this grotto. He showed me a stone seat underneath a tree close by, which, he said, was a favourite resort of the great Humboldt, a fact which increases the interest one feels in such a place. But Bertrich would be almost unknown were it not for its hot springs, 90° F., the water being impregnated with glauber salts. These springs flow into baths, in which victims of gout and rheumatism steep themselves twice daily. About 1000 patients visit Bertrich annually. The baths were known and used by the Romans, who have left many signs of their former presence in this part of Germany.

* See a drawing of it in Prof. James Thomson's paper, *Trans.*, vol. vi., page 98.

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[*Note.*—Nov., 1881.—I have taken the opportunity afforded me, when correcting the "proof" of this paper, to add the two preceding notes, and the following:—The general opinion of German geologists is that the embedded stems and branches in the Tuffstein of the Brohl Thal have not been burnt, but that they have undergone a change similar to that which may frequently be observed to have occurred in the wood which is found in thin patches in house coal, where the woody fibre is quite distinct, but as black as the rest of the coal. Had the wood been burnt or coked after having been enclosed in the Tuffstein, it would have lost at least one-third of its bulk, leaving an empty space between it and the "Tuff," but such is not the case, for it is in immediate contact with it. The theory that I have proposed obviates the latter difficulty, by supposing that the wood was charred by the falling ashes, and then floated away with them, and tightly embedded when they consolidated. The unburnt wood and leaves may have been embedded in the mass after it had assumed the condition of mud by the action of water. The German geologists do not account for the great differences in the condition of the plant remains. Among the impressions of leaves are those of two plants still living in the locality, viz., *Urtica dioica* (Lin.), and *Valeriana officinalis* (Lin.). The Tuffstein deposit belongs to the most recent geological period; Vom Rath says that it overlies the Löss, and is a "trachytisch-conglomerat." It is described in Credner's Geology as an "impure, yellowish-grey earthy mass containing fragments of pumicestone, grauwacké, clayslate, basalt, lava, and the microscope has detected numerous crystals of leucite, augite, mica, hauyne, hornblende, and sanidine-felspar."

The mouth of the Brohl valley must have been closed up (close to the point where it debouches into the Rhine valley), and the valley thus converted into a long, narrow lake, otherwise this material would have been swept onward into the Rhine before having time to consolidate into a material which is now of great value commercially.]

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[ABSTRACT.]

XXV.—NOTE *on the* REPRODUCTION *and* DEVELOPMENT *of* GRAPTOLITES. By JAMES DAIRON.

[Read 1st May, 1879.]

MR. DAIRON remarked that, though it might be thought a good deal could be said as to the reproduction and development of the Graptolitic family, such was really not the case. Though these organisms are found at the very base of the great Silurian system, and did not die out till its close, few specimens with the reproductive capsules attached are known, except in the upper Moffat beds.

Professor James Hall, of New York, seems to have been the first to describe examples of *Diplograptus Whitfieldii*, showing the ovarian sacs. This was in 1858, in his great work on the Graptolites of the Quebec group.

Dr. Alleyne Nicholson says, in his lately published monograph on the British Graptolites [Edin., 1875], that, after Professor Hall, no other observer had described such appearances, until Mr. John Hopkinson lately published an account of a specimen of *Diplograptus pristis* furnished with reproductive capsules, a figure of which Prof. Nicholson gives in the above-quoted work. This specimen was found in the Upper Llandeilo shales of Dumfriesshire. [*Annals and Mag. of Nat. Hist.*, May, 1871.]

Dr. Nicholson himself also figures *Monograptus Sedgwicki*, showing ovarian capsules growing out from between the denticles; but to this Mr. Carruthers afterwards objected, as he thought that the appearances described were due to the accidental juxtaposition of the Graptolites with the minute bodies said to be reproductive sacs. With this criticism Dr. Nicholson does not, however, agree, and says that the specimen is not thus to be explained away, but states, at the same time, that he prefers, in the absence of fresh evidence, not to insist on the correctness of his views in the meantime.

This species is one of the commonest in our Upper Silurian beds, and it is therefore remarkable, supposing the disputed bodies to be reproductive sacs, that no other specimen containing similar bodies should ever have been discovered. Mr. Dairon said that the question must at present be left as doubtful.

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The specimens now brought before the Society were two from Dobb's Linn—one of *Diplograptus pristis* and another of *Climacograptus teretiusculus*, both showing their ovarian capsules. These are of a pear-like form, and in each instance considerably differ from those of Mr. Hopkinson's specimens, which appear more ragged in form, possibly because they have discharged their contained germs. One of the specimens shows on the top of one of the capsules a circular aperture, with a lid-like covering, much the same as possessed by *Diphasia (Sertularia) operculata*, Lin. The proximal end is supported by a small fibrous membrane, the form of the capsule being well defined, and there can be no doubt it is composed of the same horny substance as the outer covering of the Graptolite itself. When the capsule had reached the proper stage it probably became dehiscent, and discharged the germs which may now be seen upon the shale near the parent organism, many of them with a dagger-like form of from $\frac{1}{8}$ to $\frac{1}{2}$ of an inch in length, and some of them having the first and second denticles attached.

As the Polyzoa have not less than three different modes of reproduction, Mr. Dairon considered it not unreasonable to suppose that there is a similar variety in the case of the Graptolites, and as the latter have entirely disappeared from existence, it is only to the nearly-allied family of Polyzoa, amongst recent forms, that we can look for any help in elucidating the various obscure points in their life-history.

[ABSTRACT.]

XXVI.—NOTES *on the* METAMORPHIC ROCKS *of* HARRIS *and* NORTH UIST. By JAMES THOMSON, F.G.S.

[Read 1st May, 1879.]

THE author first briefly referred to the opinions expressed by some of our most eminent observers regarding the stratigraphical arrangement of the rocks in Inverness-shire, Ross-shire, and Sutherlandshire, and he stated that M'Culloch and Murchison had described the rocks of the Outer Hebrides as belonging to the fundamental gneiss which has been frequently spoken of by others as the oldest in the world.

Mr. Thomson then described the characteristics of the rocks of

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Harris, including granite, granitoid-gneiss, gneiss, and conglomerate. The latter he had found interstratified with the gneiss and granitoid-gneiss. He referred to a paper by Dr. James Geikie, in the *Quarterly Journal of the Geological Society*, and said that a more faithful and graphic account of the results of ice-action he had never read; but he was surprised that Dr. Geikie had not spoken of the conglomerates found interstratified with the gneissic rocks.

At Loch Maddy, in North Uist, these rocks are much of a similar character to those of Harris, and the conglomerate rocks are seen exposed close to the pier and in front of the inn, and from this point they extend southward. Their contained fragments, pebbles, and boulders, consist of hornblende, gneiss, and granitoid rocks; while the basic rock consists of a dull blue-grey felspathic rock, with numerous patches of vitreous quartz. These erratics do not resemble fragments which had fallen from cliffs, neither do they appear to have been exposed to the action of water upon a coast line, but have a great resemblance to material found in recent boulder drift. It has been suggested that this conglomerate might belong to the pebidean beds of Dr. Hicks, but a careful survey led the author to a different conclusion, and that neither pebidean nor dimetian rocks are found in Harris or North Uist, although in Loch Carron and south of the Bay of Lucey, in Skye, the Cambrian conglomerates are seen resting on the pebidean beds, and these in turn lying on the dimetian. The latter are also well shown near Isle Ornsay.

Mr. Thomson said that the deduction he drew from the presence of these erratics in a matrix of felspar and interstratified with a series of metamorphic rocks, which have been regarded as the fundamental rocks—that there is still much to learn before any satisfactory solution of the problem can be given. In the meantime, therefore, he merely wished to record the discovery of these conglomerate beds, reserving further details for the future.

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XXVII.—Notes *on* Scottish Brachiopoda. By James Neilson, jun.

[Read 15th May, 1879.]

The subject of Carboniferous Brachiopoda has lately been of very special interest to a number of the members of this Society, from the fact that Dr. Thomas Davidson, of Brighton, has been revising his great work on the group, published by the Palæontographical Society, and is now engaged in preparing a supplement, with figures of all recent discoveries [since published, 1881].

There has therefore been a general searching for new points, and, amongst others, I have been in correspondence with Dr. Davidson regarding various matters, some of which, being quite new, I thought would be of interest to the members, more especially as, during the coming summer, there might be an opportunity of elucidating various questions not yet cleared up.

Amongst the specimens I have brought for exhibition this evening you will find representatives of nearly all the species of Brachiopoda hitherto found in Scotland, there being only seven or eight not in the collection; but I need not now speak of more than the new or rarer forms.

In the first place, I may direct your attention to a remarkable series of minute Brachiopods from weathered limestone at Dockra, near Beith, and which I had the good fortune to discover some six years ago. The decomposed rock is found, after washing, to abound with examples of various minute species, many of them being no larger than the dot of an *i* in the present type. Some of them have been hitherto regarded as very rare, while one species and one variety of another are new to Scotland.

Amongst others, I may mention the Spiriferidæ, represented here by four genera. These have an internal calcareous spire (from which their name is derived), and in some of the specimens the spire is well shown, the outer shell having been removed by acid. At a first glance these spires have a general resemblance to the ribs in the vertebrate animals, but are really in one piece, which is coiled round in a sort of cone-shaped form. Among other rare species are *Spirifer triradialis*, found at Dockra,

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Cuningham Baidland, and Waterland; *S. Carlukensis*, usually considered one of our rarest shells, but found abundantly at Dockra; and *S. ovalis*, some specimens of which were believed to be *S. pinguis*, but in error. It is doubtful if the latter has ever yet been found in Scotland.

The Producti are here represented by fifteen species, not including varieties. Amongst these may be noticed *Productus carbonarius*, which has had a very curious history. A specimen in the Jermyn Street Museum (said to have been found "in the north of Glasgow,") was figured by Dr. Davidson twenty years ago, but all subsequent search for further examples, or the exact locality, proved fruitless, and this solitary specimen remained as the only British representative of the species. However, in the late construction of the Union Railway branch line, the same species turned up in the cutting between Bellgrove and Sighthill, and was by no means rare. Most probably the Jermyn Street specimen came from the same locality, which answers to the description of being "in the north of Glasgow."

Productus complectens is a small species which lived adherent to encrinite stems and other organisms, the spines of the shell encircling and holding fast to the stem or other part of the object. These spines must have acted as ligatures interfering with growth and development, and so we find many of the encrinite stems with a swelling above a constricted portion. This species was first discovered by Mr. J. Bennie, near Dunbar. *Chonetes Laguessiana*, var. *giberula*, is new to Scotland. This specimen came from Dockra, and Mr. Young has found it also at Corrieburn. *Camerophora globulina*—from Beith—has not hitherto been recorded from that locality. *Streptorynchus crenistria*, var. *cylindrica*, from Garngad Road, was first discovered in Scotland by Mr. James Thomson, near Campbeltown, and was figured by Dr. Davidson in our *Transactions*,* under the name of *S. crenistria*, var. *robusta*. Dr. Davidson has since found that this shell is M'Coy's variety *cylindrica*, and has altered the name accordingly. *Discina Craigii* was first obtained by Mr. Robert Craig, in the Beith district. The specimen shown, which is $1\frac{3}{4}$ inches in diameter, is from Garngad Road, the only other known Scottish locality.

* Vol. ii., page 76.

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XXVIII.—Notes *on the* Perfect Condition *of the* Cell-pores *and other* Points *of* Structure *in* Certain Species *of* Carboniferous Polyzoa *from* Western Scotland. By John Young, F.G.S.

[Read 9th October, 1879.]

During recent years the beautiful and interesting group of organisms forming the Polyzoa, or Bryozoa, as they are often termed, found in the Carboniferous limestone strata of Scotland, have received a little attention, and the result has been the recognition of a number of new forms and new characters in formerly-described forms. This has led to the provisional establishment of several new genera and species described by Mr. R. Etheridge, jun., F.G.S., Dr. Young, and myself, in the *Transactions* of various societies and in scientific journals of this country. These forms have chiefly been obtained from the Carboniferous limestone shales of Western Scotland, in which Polyzoa are abundant and generally well preserved. Having formed a pretty large collection of these organisms, now numbering some 40 good species and embracing 16 genera, I am now able to offer a few remarks on what I believe to be the perfect condition of the cell-pores and other points of structure in several of the species, which may, perhaps, enable future investigators to place them in their proper zoological position among the Polyzoa. I think that much importance will yet come to be attached to the perfect condition of the cell-pores and other points of structure, and that any new discoveries in this line of research will in the future be considered of much more importance than the mere finding of new genera or species.

In the *Quarterly Journal* of the Geological Society for 1874, Dr. Young and I called the attention of palæontologists to what we consider the perfect form of cell-pores in one form of the genera *Fenestella* and *Glauconome*, in which the cells are closed by eight slender converging rays or denticles, and in which a very small secondary pore or pit is seen to be placed close to and in line with every rayed cell. Previous to our discovery no similar structure of cells had ever been described in either of these two genera, and as we believed these new and peculiar characters were sufficient to enable us to establish new generic and specific distinctions for these forms, we named the first *Actinostoma*

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fenestratum, and the second *Glauconome stellipora*. Since that time I have found, I believe, the rayed cells in another of the *Fenestella*, which approaches *F. tenuifila*, Phillips, in character. In this last form, however, the rayed cells have not been so well preserved, but I still hope that better specimens will turn up to prove the point. These rays or denticles seem to have been very easily abraded and destroyed, and in most cases this is seen to have been done before the fronds of the Polyzoa were entombed in the sediments in which they now lie. When this is the case the cell mouths have a rather ragged appearance when partially worn, and when fully worn they are round openings, as in the cell-pores of ordinary *Fenestella*. Fronds of *Actinostoma* in my collection show in the same specimen every condition, from the perfect rayed pore to the round open cell. It is, therefore, only the most perfectly-preserved specimens which show the peculiar characters upon which the genus is founded.

In the *Geological Magazine* for June, 1877, Dr. Young and I called attention, in a short note, to another form of cell-pore which I had discovered in certain Carboniferous Polyzoa, and which I am now inclined to believe is the perfect cell-pore of these forms. In it the mouths of the cell-pores are covered by a thin calcareous disc or diaphragm pierced in the centre by a very minute pore just visible with an ordinary pocket lens, but well seen under a low power of the microscope. At first we had some doubt as to whether this calcareous layer was not due to subsequent incrustation over the face of the Polyzoa on which it occurs, the cells being kept open through the small pores by the organism itself or by other agencies. Now, however, I have found it in the following species—*Fenestella plebeia*, M'Coy; *F. ejuncida*, M'Coy; *Polypora tuberculata*, Prout; and *Glauconome elegans*, Young and Young; and in specimens from different horizons of strata. I therefore believe that it is only another condition of the perfect cell-pore in these forms of Polyzoa, and if this view should prove correct it will perhaps necessitate the separation of the forms possessing this character from the genera amongst which they are at present located. The localities from which I have obtained Polyzoa showing this character are the limestone shales of Hairmyres, East Kilbride; and Newfield and Dykehead, High Blantyre. The same remarks, which, as I have already stated in speaking of the *Actinostoma*, apply equally to the preservation of the cells in these

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forms only the most perfectly preserved fronds show the thin diaphragm covering the cells, while, if the specimens are the least worn, the cells are seen to be round and open.

In *Diastopora (Bernicea) megastoma* (M'Coy) we have an encrusting Polyzoon which is very abundant in the limestone shales of the West of Scotland. This species is described by M'Coy as having the cells very large, prominent, and of a semi-circular form, and having a raised edge only to the superior half of the margin. Our specimens show that the cells were of a trilobed form, having two small tooth-like projections on the upper lip of the cell; but, in addition, I have been fortunate in finding in the shales of Capelrig, East Kilbride, examples of this species, showing besides that the perfect cells were closed by a thin calcareous cover, pierced by a narrow transverse slit or opening just under the raised lip of the cell; and, further, that amongst the cells there is a minute cellular structure, best seen on slightly worn specimens. None of these characters are noticed in the description of the species by M'Coy, and I therefore bring them before the Society for the first time, as an additional contribution to the perfect cell structure of this species.

From the shales of Capelrig I have also another incrusting organism attached to a crinoid stem, which so much resembles the incrusting form of the coral *Stenopora tumida*—if that is really a coral—that I have hitherto been inclined to identify this specimen with that species. I now, however, begin to have some doubts on the subject, from the fact that in this specimen the hexagonal cells are closed by a neat, thin, calcareous cover, pierced by a small pore or opening placed in one of the angles of the cells, and which in the numerous cells is quite regular in its position. I am not aware that *S. tumida* or any allied coral has ever been described as having the cells closed by a perforated calcareous disc. In this respect it more resembles the Polyzoa I have noticed in this paper, but I know of no incrusting Polyzoa with hexagonal cells having been described from British Carboniferous strata. The specimen here noticed is in a beautiful state of preservation, and I bring it before the Society in the hope that more light may yet be thrown upon it.

Having gained a knowledge of the fact that certain of the Carboniferous Polyzoa have their cells closed in, either by rayed denticles or calcareous diaphragms, may we not, therefore, reasonably conclude that in many of the other forms belonging to the

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same or closely allied genera they had also similarly constructed cells, but that, owing to the state of preservation in which the latter have been found, these new characters have not as yet been noticed? It is, however, probable that when better preserved specimens turn up some of these characters will yet be discovered. It is therefore very desirable that every specimen which falls into the hands of collectors should be carefully examined under the microscope. Of the 40 species which I have found in our limestone strata the genera of *Fenestella* and *Glauconome* are most numerously represented. In a recent paper by Mr. G. W. Shrubsole in the *Quarterly Journal* of the Geological Society, for May, 1879, he reviews the species of the British Carboniferous Fenestellidæ. He states that of the 26 described species, he finds he can reduce them to five. While, however, I quite agree with Mr. Shrubsole that a number of the species have been founded upon imperfectly preserved fragments, in which some of the external characters were probably obscured, and which must now be regarded as synonyms of the species he admits, yet he seems to have failed in recognising some important distinctions which mark at least one or two of the Scottish forms. I here refer to his confounding *Fenestella plebeia* (M'Coy) with *F. tuberculocarinata* (Etheridge, jun.). These are the two most abundant Scottish forms, and as found in our beds are quite distinct under every aspect; the former having four pores on the average to each side of the length of the fenestrule, while the latter has only three. I have found these characters are constant in a large series of specimens.

After a careful examination of my specimens I find that we have at least eight good species of the genus, exclusive of *Actinostoma*, now a sub-genus of the Fenestellidæ. The external characters upon which I rely are chiefly the number of pores in the length of the fenestrule, their size and form, with other surface markings; and now by the asphalte process which I have adopted, whereby large fronds can be mounted with their celluliferous face upwards, the constant character as to the number of pores can easily be traced over comparatively large surfaces of the polyzoarium.

Before passing away from the Fenestellidæ, I may mention another character which I have discovered, while preparing transparent sections for the microscope, the significance of which in relation to the organism is not yet fully understood. When portions of the fronds of *Fenestella* are ground down so as to show

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the middle of the cells, a small tooth-like projection is then seen, placed on the outer wall of the cell on each side of the interstice. This is beautifully seen on one specimen of *Fenestella multiporata*, and also on *F. plebeia*, and is probably characteristic of other species of the genus. It was also independently discovered by Mr. A. W. Waters, and was figured and described by him in the *Transactions* of the Manchester Geological Society for 1878, from specimens sent him from Hairmyres, East Kilbride. In his figure and description two denticles or teeth are shown in each cell, one on each side, whereas all my specimens show only one tooth, which, as previously stated, is placed on the outer wall and projects obliquely upwards into the cell. If there is no mistake in the understanding of Mr. Waters' section of the polyzoon, it may probably be a different species from those which I have examined.*

In the *Quarterly Journal* of the Geological Society for 1874, Dr. Young and I discussed the affinities of the organic processes found projecting from the fronds of the fenestrated species of the Polyzoa, termed *Palæocoryne* by Prof. Duncan and Mr. Jenkins. We showed by figures of numerous specimens that they had no hydrozoal affinities, as we considered that they were merely processes developed from the fronds of the polyzoon, to which they were seen to be organically attached, not incrusting or parasitically attached, nor closing up numerous cell-pores as stated by Duncan and Jenkins, as several well-preserved specimens testify. Our views were not accepted by the above-named gentlemen, but I am glad to see that one or two observers of the fenestrated Polyzoa since that date agree with us that these processes are part and parcel of the organisms. Further information on the *Palæocoryne* and on the development of the Fenestellidæ may be found in an interesting paper in *Science Gossip* for October, 1879, by Mr. G. R. Vine of Sheffield.

* Since the above was written, I have discovered that the small tooth-like projections are due to a sudden infolding of one edge of the outer cell wall at that point where the cells bend from their nearly vertical position within the interstices, so as to allow their circular orifices or mouths to open on the face of the frond at almost right angles to that of the lower portion of the cells. This feature is well seen in one or two recent sections which I have made, as well as in etched specimens of the celluliferous surface of fronds. These show clearly that the infolding only takes place on the outer edge of the cell, and that consequently there is only one tooth-like projection in each cell, it being the infolded portion of the cell wall.

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The genus *Glauconome*, as found in our beds, is represented by some eight or nine apparently good species, which are easily distinguishable from one another by various external characters. They have been examined by Dr. Young and myself, and as we failed in getting any descriptions or figures of the genus found in other Carboniferous strata which agreed with the characters of our Scottish specimens, we have been forced provisionally to describe and figure the group as new in the *Proceedings* of the Natural History Society of Glasgow. Whether we were right or wrong in doing so with all the species, we leave in the hands of future investigators of the group to declare.

Of the other 14 genera of Carboniferous Polyzoa which are found in our limestone strata, the greater number are represented by only one species, others by two or three, all having good distinguishing external characters by which they may be easily known. For a complete list to date, see the Catalogue of Western Scottish Fossils prepared for the meeting of the British Association in 1876. In the *Annals and Magazine of Natural History* for 1874, Dr. Young and I called attention to a new internal point of structure in one of the Polyzoa—the *Millepora gracilis* of Phillips,—and I have also discovered the same character in *M. rhombifera* of the same author. In these species we showed that the cells are arranged in a spiral form around a central tubular axis or rod, a character not previously noticed in any polyzoon recent or fossil. For these forms we established the genus *Rhabdomeson*, the two species of Phillips mentioned above being noted as *R. gracile* and *R. rhombiferum*. We stated in our paper that beautiful natural sections of the organisms were found in the white polyzoan band of limestone in Trearne Quarry, near Beith, showing the middle rod around which the cells are arranged in a very clear manner, when the organism happens to be split lengthways. Since that date even better preserved examples have turned up in the same bed. At Auchenskeoch Quarry, Dalry, I recently found on a slab of shale a branching specimen of *R. gracile* which showed that the organism sometimes attained a length of six inches or more, and that its surface ornamentation was very spinulose around the margins of the cell openings when well preserved.

Other researches among branching forms of Polyzoa with nearly the same habit of growth as *Rhabdomeson* have failed as yet in finding any middle axis, and probably in those it did not exist. I

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still think, however, that many interesting points yet remain to be discovered in the Carboniferous Polyzoa, both as to the perfect form of cells and other points of internal structure. I say so all the more readily from a knowledge that all the facts of interest noted in this paper, whether regarding the discovery of new points of structure in the Polyzoa, or the descriptions of new species by Dr. Young, myself, and other investigators, are the result of work conducted at intervals only during the past six years. I have no doubt, therefore, that continued research will reveal many other points of interest and value regarding this till lately comparatively unworked but extensive and interesting group.

[ABSTRACT.]

XXIX.—*On* ROCKS *and* MINERALS *in* CORNWALL. By JAMES WHITE.

[Read 13th November, 1879.]

MR. WHITE said that the strata in Cornwall are chiefly Devonian, but are much broken up and metamorphosed by the action of igneous rocks, traps, porphyries (locally known as "Elvans"), and granites. These latter are of many varieties of hardness and texture, and are used—the harder, for ornamental and heavy building purposes, like our own Aberdeen, Peterhead, and Mull granites; the softer and more earthy varieties, for the manufacture of china clay, of which about 80,000 tons are produced annually. London Bridge, and Waterloo Bridge, in London, and the docks at Chatham, are built of Cornish granite. The chief feature of the county, however, and that which has brought Cornwall its greatest riches, is the abundance of its metallic veins. The Cornish mines have been known and worked from time immemorial, in the ordinary, though not the geological, sense of that well-worn phrase; it is known that long before the Christian era Phœnician sailors visited the coast and other parts of the county for the purpose of trading in tin and various other metals. Tin occurs nowhere else in the British islands, and is here found in two forms—stream tin and vein tin. The former is found from the size of small grains to lumps of 10lbs. to 12lbs. weight, while occasionally large masses of rock occur richly impregnated with the mineral. These are found scattered over the surface of the hard

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rocks and overlaid by soft deposits, and are also got in gullies and water-courses. As stream tin is found principally on the south coast—or to the south of the tin veins, which run chiefly east and west,—it seems probable that it once formed portions of veins broken up and scattered by denudation, and, after being rolled about on the rock surfaces, was covered by the overlying deposits. It is usually of purer quality than the vein tin, and is now becoming scarcer. So thorough has been the search for it, that it is stated there is not a square foot of the south coast which has not been turned over repeatedly for examination, workings which have been abandoned being again and again re-opened as the supply diminished and an enhanced price paid. It is, therefore, impossible now to find a fresh section anywhere. It may easily be imagined that there is not much natural beauty remaining in the scene of these workings. One traveller describes the appearance of the country as "bare, desolate, and impracticable, broken and dug into numerous hillocks, sometimes due to primeval stream-works, sometimes to the more modern search for metals," and he goes on to state that "the drive from Launceston to Penzance, a distance of 70 miles right across the county from east to west, is over one of the most dreary strips of earth to be found anywhere in the British Islands." Vein tin occurs, as its name implies, in veins which have been formed in cracks and fissures of the rocky crust of the county. These veins, or "lodes," as they are termed, intersect all kinds of strata, igneous and aqueous alike, and are of all degrees of thickness, from the merest film to that of 30 or 40 feet. They are sometimes mined to enormous depths; one of the deepest is Tresavean Mine, which is 320 fathoms, a depth nearly equal to five times the height of St. Rollox great chimney. The temperature at this depth is about 100 degrees Fahrenheit, and the miners work their eight hours per day naked to the waist. Copper, lead, antimony, hematite iron, and other minerals are also worked—copper, after tin, being the most abundant, and being usually found at lower depths than that metal. The Cornish copper-mines yield about 90 per cent. of all that is found in Britain, and about 30 per cent. of the whole European supply. The total number of metalliferous mines and stream-works in Cornwall is 224. Mr. White also spoke of the micaceous trap, micaceous iron ore, tourmaline schist, potstone, &c.

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XXX.—*On the* Occurrence *of* Euxenite *and other* Rare Minerals *in* Veins *of* Graphic Granite *at* Hitterö, Flekkefjord, Norway. By J. J. Dobbie, M.A., D.Sc.

[Read 4th December, 1879.]

The paper which I have the honour to read to-night is entirely descriptive. I cannot, therefore, expect that it will have for you the interest which attaches to the argument of a theory, but I trust that it may not be without a certain value in helping to illustrate or elucidate geological structures similar to what I have to describe, which may have come under the notice of members of this Society. Hitterö, or Hitter Island—ö being Norse for an island—lies on the south-west coast of Norway, about mid-way between Christiansand and Stavanger, at the mouth of Flekkefjord, one of the smaller but most beautiful of the numberless Norwegian lochs. Except on account of its mineral treasures, which appear to be known to comparatively few, Hitterö possesses no special interest for the traveller, and is seldom visited. We were told, indeed, that we were the first English who had ever been there, but this we afterwards learned was a mistake—the agent of a fish-curer had been before us. The island lies off the regular tourist routes, and is not very readily accessible. For the opportunity of visiting it my friend Dr. Wm. Ramsay, who accompanied me on my trip, and myself were entirely indebted to the kindness of Dr. Amund Helland of the University of Christiania, a geologist well known by his writings on ice-action.

Hitter Island is not much larger than our Great Cumbrae. It is very precipitous, and landing is only possible at one or two points, where the rock has been worn down by streams. The whole of the island is beautifully smoothed and rounded by ice-action, the striation in some places being wonderfully distinct. The rock of which the island is composed is of a dark brown colour, coarse-grained, and highly crystalline. It possesses a peculiar structure which imitates the appearance of stratification in a rude but very striking way. The dip of this pseudo-stratification varies in direction, being in some places E.N.E., in others W.S.W. For petrologists the rock of Hitterö is a classic one, because it was to it that Esmark first applied the term "Norite."

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This term is often used loosely as an equivalent for gabbro, but, according to the classification of Professor Rosenbusch, Norite differs essentially from gabbro in containing hypersthene in place of diallage. Gabbro is a mixture of a plagioclase felspar with diallage; Norite, a mixture of a plagioclase felspar with hypersthene. Microscopic investigation seems to have established that the rock, according to this classification, is a true Norite.* Rutley, in his "Study of Rocks," says—"The Norites of Hitterö consist of plagioclase and hypersthene, in which the interposed plates, &c., so characteristic of the typical hypersthene, are very generally absent."† In connection with this question I may mention that I picked up several large pieces of undoubted hypersthene at a spot where the rock had been broken down in working the granite veins which occur in the north-west of the island. We visited five veins, all apparently distinct from one another.

These veins dip S.S.E. at an angle of about 15°. Their prevailing thickness is from 3 to 4 yards, increasing occasionally to as much as 7 yards. Except that it is somewhat coarser in texture, the Norite does not appear to be in any way altered by contact with the granite. The larger veins send off shoots into the Norite, and here and there pieces of Norite are completely enclosed by the granite. One of the veins is accompanied by hornblendic gneiss. The granite, which was formerly worked for its felspar, varies much in texture, passing from a coarse ternary granite, in which the component minerals assume gigantic proportions, into a comparatively fine-grained binary granite, having the crystals of felspar and quartz plated together in the manner characteristic of what is usually understood by the term *graphic granite.* Some idea of the large-grained variety may be formed when I mention that we saw, protruding from the roof and sides of the workings, crystals of quartz large enough to form the shafts of columns. One plate of mica, which I brought home, and which I split from a crystal about two feet thick, measures 26½ inches by 15¼ inches. The prevailing felspar of the veins is of a pale flesh colour. In general characters it closely resembles orthoclase, but is in reality a mikroklin, *i.e.*, a felspar having the same chemical composition

* Beautiful sections of this rock have been made by the late Mr. Arthur Pratt, a member of this Society.

† Rutley, "The Study of Rocks," p. 251.

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as orthoclase, but differing in the angle at which the two principal cleavage planes are inclined to one another. Potash felspar is in reality dimorphic. It crystallizes both in the monoclinic and in the triclinic systems. Mikroklin is the triclinic or plagioclastic form. Besides mikroklin, a white triclinic felspar, probably oligoclase, with beautiful striæ upon the face of basal cleavage is abundant, and I picked up one specimen of a curious dark-coloured felspar, with curved faces and strongly striated. The quartz of the veins presents interesting peculiarities. Some of the specimens are quite milky, or even opaque, from the presence of numberless cavities. These cavities are filled with fluid, and many of them contain crystals of common salt, and sometimes, in the same cavity with the salt, bubbles of a gas which appears to be carbonic acid. Dr. Helland has studied these cavities with great care.* When we visited Christiania he showed us sections with cavities containing crystals of common salt and *two* bubbles, one within the other. He supposed the cavity to be filled with a saturated solution of common salt, from which the crystals had separated. The larger bubble he held to be liquid carbonic acid, floating like an oil globule in the solution of salt, and the inner globule carbonic acid in the gaseous state. The inner bubble appeared to be in a state of constant vibration, which ceased when the section was heated by passing the flame of a spirit lamp under the microscopic slide, but recommenced as soon as the slide cooled down. The mica of the veins is for the most part a black biotite, but a beautiful transparent muscovite also occurs in small quantity.

The rare minerals occur in the form of lumps or nuggets, scattered indifferently through all parts of the veins, being sometimes embedded in the fine and sometimes in the coarse-grained granite. The orthite is frequently embedded in felspar, and when this is the case the felspar has a peculiar radiated texture, the fibres proceeding from the nugget of the orthite as from a centre. One specimen which I brought home with me is very interesting. It is wedge-shaped, the sides of the wedge being composed of thick plates of black mica. Between the mica plates the rare minerals are arranged in layers which alternate with layers of quartz. A wedge-shaped piece of quartz occupies the apex.

Prof. Waage, of Christiania, who is a native of Hitterö, and has

* Archiv. for Mathematik og Naturvidenskab. Kristiania, 1876.

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made a special study of some of its minerals, has found the following in the veins:—euxenite, polykras, orthite, gadolinite, malakon, ytterspar, monazite, molybdenum-glance, besides ilmenite and other minerals of commoner occurrence. Euxenite is, so far as we could judge, the most abundant of these minerals. This mineral is a double titanate and niobate of yttrium and erbium, and contains uranium and iron, as well as small quantities of cerium, lanthanum, and didymium. In general appearance, in colour and lustre, it resembles some varieties of coal, but may at once be distinguished by its high specific gravity, which in pure specimens is as high as 5. It is readily distinguished from orthite by its red-coloured streak and by transmitting red light when cut in thin sections. It occurs both crystalline and massive, but the form has not been satisfactorily determined. According to some authorities it is rhombic, according to others monoclinic. Polykras contains the same elements as euxenite, but differs from it essentially in crystalline form. It usually occurs in thin table-shaped six-sided crystals.

Orthite, which is isomorphous with epidote, is a mineral of very complicated composition. It usually contains silica, iron, alumina, cerium, lanthanum, lime, and magnesia, and sometimes a considerable percentage of yttrium. It is a black mineral, of lower specific gravity than euxenite, from which it is readily distinguished by the characters already mentioned, as well as by its greasy or resinous lustre.

The Hitterö gadolinite, of which we only obtained one specimen, contains a much larger percentage of beryllium than the varieties from other localities. Besides beryllium, the usual constituents of the mineral are silica, iron, cerium, and yttrium. Gadolinite is a black mineral, with vitreous lustre and green-gray coloured streak. We found several good crystals of malakon, a mineral closely allied to zirkon, but differing from it in containing about 3 per cent. of water.

Veins of graphic granite, similar to those of Hitterö, occur at Arendal, on the south coast of Norway, between Christiansand and Christiania. The parent rock at Arendal is, however, not a norite, but gneiss, and the veins contain thorite in addition to most of the minerals found in those of Hitterö.

With regard to the origin of the Hitterö veins, I must confess my inability to form any probable conjecture.

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XXXI.—Notes *on some* Carboniferous Lamellibranchs. *Their Mode of Occurrence and observed Shell-structure.* By John Young, F.G.S.

[Read 13th January, 1880.]

In the strata of our upper coal measures, as well as in the coal measures that form the middle division of the Scottish Carboniferous limestone series, we find a small group of mytiliform shells, which were formerly referred to the marine genus *Myalina;* but as they were found not to possess the thick hinge-plate of this genus, and to differ in some other particulars, they were erected into a new genus in 1863 by the late J. W. Salter, under the name of *Anthracoptera*—literally coal-wing—from being found in strata alternating with our coal-seams, and this name has since been retained.

The genus is represented in our beds by at least three species, *Anthracoptera carinata, A. modiolaris,* and *A. quadrata.* These are often found to be associated in the same beds with the group of shells formerly termed Coal *Unios,* but which have now received the generic names of *Anthracosia* and *Anthracomya.* These three genera seem to have been gregarious in their habits, their shells being seen to enter largely into the composition of our mussel-band ironstones, and mussel-band oil shales.

Formerly this group, from being found associated in some localities with strata containing marine shells, was also believed to be of marine origin. But this has always been a point of doubt in the minds of many palæontologists, especially as this group of mollusca has never yet been met with in the same stratum along with the typical marine organisms of the period. The belief is now largely entertained that the *Anthracosia* group of shells lived in fresh-water lakes and estuaries, at times brackish, and which, from oscillations of the land, may have been covered by the sea over certain tracts for a period, marine conditions in the strata that lie over, and sometimes alternate with, the fresh-water shell beds, being thus brought about. As far as Scotland is concerned, I have never observed any commingling of true marine fossils in any of our mussel-band beds. The reptiles, fishes, molluscs, annelids, ostracods, and other organisms belong to

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genera and species that are seldom or never met with in marine limestone strata. This being the case, I believe the opinion formerly entertained, as to the marine origin of the strata of our upper and middle coal measures, especially of the beds characterized by the *Anthracosia*, was an opinion based on faulty observation, and which will yet be proved to be untrue, when the fossils occupying each horizon of strata come to be critically examined. Oscillations of the earth's crust may bring strata, which have been deposited under either lacustrine or estuarine conditions, into very close contact with those of true oceanic deposits, and this may be repeated again and again in the same series of beds. It becomes therefore the work of the palæontologist to say which of the organisms found in this commingling of beds properly belong to the sea, and which to lakes and rivers.

There had hitherto been no group of our Carboniferous mollusca so little understood, and the species of which had been placed in so many different genera, as the so-called Coal *Unios*, previous to the time when some of them were taken up for description by Professor King and Mr. Salter—*Cardinia*, *Pachyodon*, and *Carbonicola*, are some of the names by which *Anthracosia* was formerly known.

I have now to notice a point of structure in the shell of *Anthracoptera* that apparently has not yet been recorded. While recently looking over the surface of some of my shells under the microscope, I was interested in finding a beautiful prismatic cellular structure in many of the specimens still retaining their shell, and in which the substance of the shell had not been too much mineralized. This structure is similar and quite comparable with that so beautifully seen in the shells of recent *Pinnæ*, the prismatic structure presenting a kind of hexagonal or minute honeycombed appearance. The finding of this structure in *Anthracoptera* has led me to examine the surface of several other Carboniferous lamellibranch shells from Western Scotland, and I have been fortunate in finding the same kind of structure in the following genera, viz.:—*Pinna*, *Pteronites*, *Posidonomya*, and *Myalina*. I examined the surface of the shell of *Anthracomya*. Mr. Salter has pointed out that the surface of the shell in this genus has a strongly wrinkled epidermis, the shell itself being thin. Unfortunately, none of my specimens retain the shell, so I cannot say whether it had a prismatic structure or not. I have also looked at *Anthracosia*, which has a moderately thick shell when it is preserved,

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but I failed in finding any prismatic cellular structure in it. The examination of the intimate shell-structure of our Carboniferous fossils is an interesting branch of investigation, and one in which a great deal of work still remains to be done, as localities may turn up in which the structure of the organisms is much more finely preserved than that of others. I have recently found this to be the case when examining the shell-structure of the brachiopoda found in our beds. In some localities, owing to mineralization, no structure is to be discerned, while other localities have yielded specimens which have revealed points of structure and other external characters not previously noted in this group. So far as I have examined my Carboniferous lamellibranchs, I find that this prismatic cellular structure is confined to shells belonging to the Aviculidæ or wing-shells, and the Mytilidæ or mussels, thus agreeing with what is known of the shell-structure of the recent species in these families. All these shells possess more or less a distinctly fibrous structure, and it is the arrangement of these fibrous bundles that produces the beautiful prismatic cellular structure seen when viewed through the microscope in transparent horizontal sections. In the Carboniferous *Aviculopectens* which are placed amongst the Aviculidæ, I have sought for structure in their shells, but, probably owing to mineralization, I have failed in detecting it in most specimens; but in a smooth species of the genus from Craigenglen, Campsie, I have found a beautiful microscopic ornamentation, forming a reticulated kind of pattern on the surface of the shell, which, if not due to similar structure, at least belongs to a like kind of ornamentation of the surface, and which, the shell being very thin in this species, may pass for a short distance into its substance. Dr. Carpenter has pointed out that, in many recent shells where the cellular structure has been detected, it is often confined to a very thin layer below the surface epidermis of the shell, and it has likewise been found in both fresh-water and marine bivalves, thus agreeing with what I have myself observed in the Carboniferous species from Western Scotland.

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XXXII.—*The* Oils *and* Oil-wells *of* Burma, *with* Notes *on the* Geology *of the* Districts *of their* Occurrence. By James R. M. Robertson, M.D., C.M., F.R.G.S., Renfrew. With a Plate [No. VII.].

[Read 12th February, 1880.]

At the request of some of the oldest and most esteemed members of your Society, I propose this evening to give you a short account of the more salient geological features of those areas of Burma over which petroleum or earth-oils have been found, with an account of some investigations I personally superintended connected with the existence and occurrence of these oils.

A reference to the map will show you that British Burma consists of a narrow strip of territory that forms the eastern coast of the Bay of Bengal. This territory is divided into three provinces. The northern portion, stretching from Cape Negrais on the south to Assam on the north, is called Arrakan; the middle portion, comprising the valleys of the great rivers Irrawadi and Sittang, is known as Pegu; while the wild mountainous tract to the south of this, from Moulmein on the north, southwards to the Isthmus of Kraw, and having the Shaw kingdom of Siam on the east, is called Tennaserim. The independent kingdom of Upper Burma is therefore completely enclosed on the south and west by Arrakan and Pegu. Of Upper Burma itself, apart from a few districts adjoining the Irrawadi, and below Ava, comparatively little of a precise or reliable character is known. It may almost be considered as a mysterious land, over which the all-pervading foot of the all-pervading Britisher has not as yet wandered.

Tennaserim is a very rugged, mountainous region, covered with a dense tropical jungle, peopled by wild races of Karens, and is practically unexplored. The mountain ranges are for the most part composed of granite, and in parts they are metalliferous, as in the vicinity and to the south of Mergui, where quantities of tin, found as stream ore, have long been collected and smelted by Chinese. A few years ago an English firm—allured, it is said, by the flattering reports of the government geologist—took up a large tin concession, with most disastrous pecuniary results. South of this, at Renoung, Junkselon, Quettah, and the states along the

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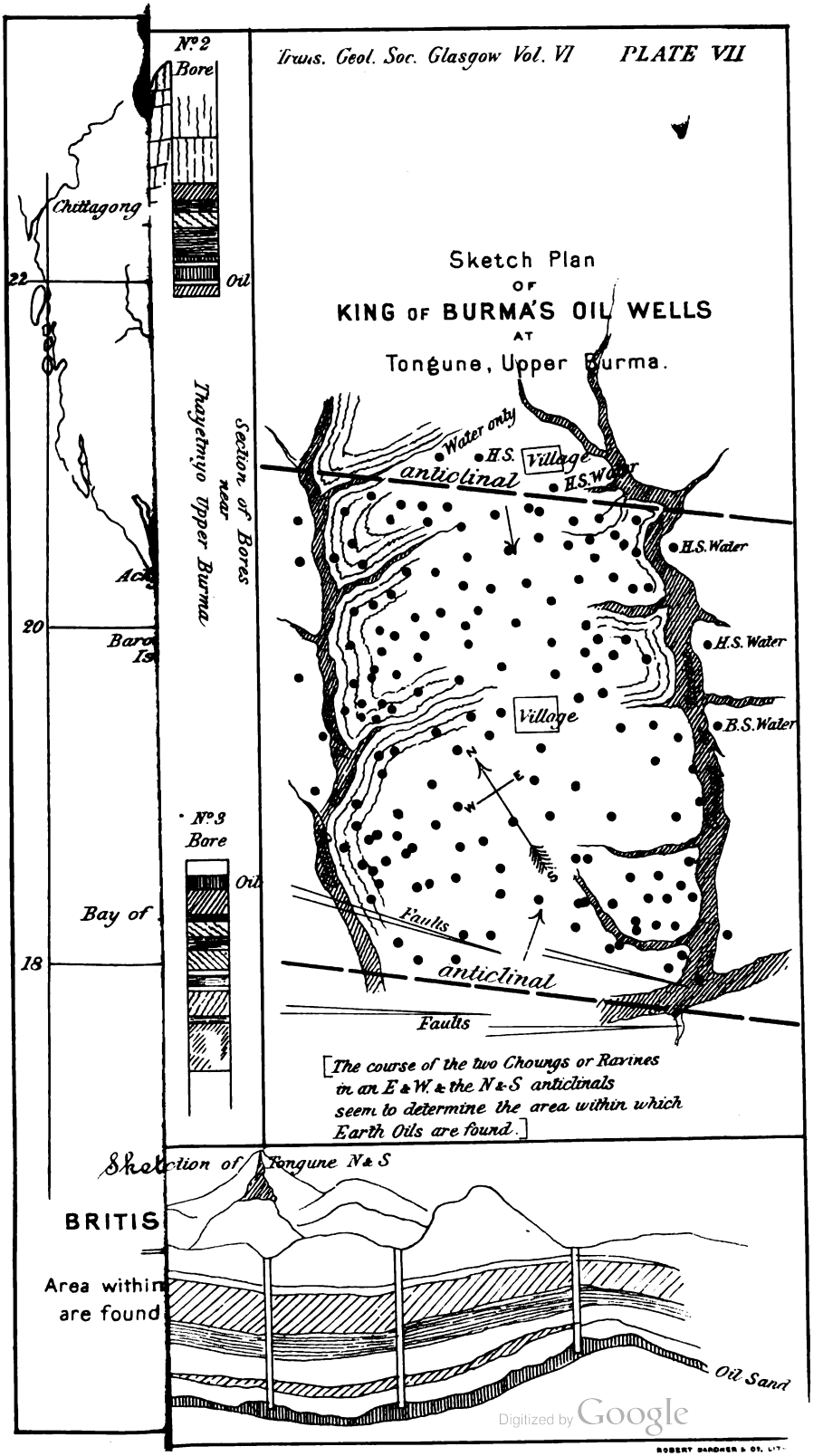

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Malayan peninsula (which is but a prolongation towards the south and east of the Tennaserim mountains), large quantities of stream tin are found, and it is collected and smelted solely by industrious Chinese. North of Moulmein, copper and gold in small quantities have been found, while in the vicinity of Toungoo Fort, as well as in Magway island, near Mergui, galena, containing about 20 oz. of silver to the ton of ore, occurs.

Pegu, for the most part, consists of the flat and fertile valleys of the Irrawadi and Sittang rivers. These valleys are separated for the greater part of their length by the Pegu "yoma" or range of hills that runs parallel with the rivers. On the borders of Upper and Lower Burma spurs from the Arrakan range approach those of the Pegu range, and between these the great river Irrawadi is for some miles enclosed in a narrow defile. On the eastern side these spurs are composed of mottled sandstones, indurated clays, and shales and bands of lime—in one situation below Thayetmyo —the great frontier British fort—a thin capricious deposit of dirty coal is seen—and all beds composing them are tilted up at a high angle. The shales or arenaceous clays enclose many accessary blocks of rounded calcareous nodules, generally of oblong shape. The limestone, in parts fossiliferous, is coarse-grained, very hard, and of marine origin. In one or two situations hot mineral springs are found.

Arrakan is a narrow mountainous strip of territory. The coast line is irregular, and in the southern part it is bold and deeply indented with creeks. From the districts surrounding Chittagong, Ackyab, and the minor southern ports, a very large amount of rice, called "paddi," is raised; but in the great plains of Pegu—the fertility of which is in no way dependent upon the uncertain advent of rain, but on the annual rise of the muddy waters of the Irrawadi—enormous quantities of grain are grown. Out of the 44,000 square miles fit for cultivation, under 4,000 are cleared; and from this small area, after supplying all their own demands as well as those of Upper Burma, which is dependent upon Pegu for the food supplies for her people, about 1,200,000 tons of rice are annually exported. It is indeed a veritable paddi land, differing, however, from our own Emerald isle in this respect—that in India the peaceful and contented ryouts, or husbandmen, raise the paddi, whereas in Ireland it is the ignorant and discontented paddy who raises the riots.

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Over a large portion of Burma the coast line is low, and there is a perfect network of anastamosing water-ways, nowhere better seen than in the great littoral plain at the mouths of the Irrawadi.

With the exception of that part of Upper Burma extending northward from a little below Ava, where rocks of secondary age prevail, the whole of Burma—and, for that matter, the east region of Assam and lower Bengal—is covered with Tertiary strata. The Arrakan and Pegu ranges are evidently of recent formation, having been forced through pre-existing Tertiary rocks of Miocene or Eocene age—these latter being piled and tilted up, folded and contorted for some distances along their base, and bearing evidence of being subjected to severe lateral pressure.

If you again refer to the map you will observe on the west coast of Arrakan the position of Ackyab, and further south the coast town of Sandoway. These two towns are distant from each other about 140 miles—roughly speaking, two degrees of latitude. You will observe that from these I have drawn two white lines in a north-east direction, the one touching the Irrawadi at the old sacred city of Paghan, and the other at Kama, a few miles south of the frontier city of Thayetmyo. These two parallel lines delineate very accurately the zone between which earth oil is found. Eastwards of the Irrawadi little or nothing is known. I propose, therefore, to confine the following remarks to the large area of country comprised between these boundary lines.

On the west coast, between Ackyab and Sandoway, there are a number of islands of considerable extent. Immediately north of the latter the two largest islands are those of Cheduba and Ramri, while immediately south of Ackyab the *three* narrow and parallel islands called the Barongahs deserve notice.

Cheduba, in the south, may be described as a fertile, well-wooded island of moderate height and irregular outline. It is surrounded by a level plain that is only a little elevated above the sea. Within this lie irregular and low undulating hills, varying from 50 to 500 feet in height, which again enclose several higher eminences, the highest of which rises, it is said, to a height of 1,400 feet. The whole is covered by a luxuriant jungle. A short distance to the south of this are two islands named "Round" and "Flat" islands, which were elevated above the sea so recently as 1752. Their appearance was accompanied by a violent earthquake, and at the same time Cheduba itself was elevated 20 feet.

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The larger island of Ramri adjoins Cheduba to the north, and is only separated from the mainland by a narrow and shallow strait, and may be said to be intimately connected with the adjoining Arrakan mountains. It is, like Cheduba, composed for the most part of soft sandstones and shales of irregular dip and strike. The hills, consequent on the softness of the strata or rocks, are, as a rule, featureless in outline. The general direction of the ridges is N.W. by S.E., and in Ramri, as in Cheduba, the highest points are to the south, one of them rising to the height of 2,000 feet. The coastline is most irregular, being penetrated by many fiords or creeks, and these in one or two parts all but intersect it.

The Barongah islands are similar in character; each consists of an elevated ridge of mountains, surrounded by flat fertile plains of no great breadth. The rocks composing all the islands are of similar character, consisting almost entirely of arenaceous shales and soft sandstones. These are obscurely bedded, and cannot, or can only with great difficulty, be correlated with exposed faces in the neighbourhood. They are devoid of distinctive features—or indexes, or landmarks, if you will—by which they may be recognised in neighbouring or distant localities, and this statement applies to the whole of the areas under consideration. The shales readily pass into arenaceous fire-clays, and enclose many irregular nodules or short strangulated beds of calcareous sandstone, with tolerably pure bluish limestone, and are not unfrequently traversed by calcspar or talc. The sandstones are soft, reddish-grey, green, or yellow, seldom white, often mottled. Sometimes these sandstones are rough, at other places fine grained, and are characterised by false bedding. Patches of them are calcareous, and are traversed by thin veins of talc. During the hot season exposed beds of these rocks are covered by an abundant efflorescence, composed for the most part of lime and magnesia.

In Cheduba and Ramri both shales and sandstones often enclose little irregular strings or lenticular masses of lignite, from 1″ to 5″ in thickness, and seldom more than 18″ long. In Ramri several outcrops of carbonaceous matter, called by the Government geologists "coal," are seen near to Toetsama, on the S.E. coast. It occurs at the base of a ridge of hills about 300 feet high, composed of sandstone and shale or fire-clay. The coally "blaes," as it would be called in this neighbourhood, consists of streaks or irregular layers of carbonaceous matter, lying between bands of

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"blaes" or clay. They lie at a high angle, are strongly laminated and jointed, fall to pieces easily, and are perfectly valueless as fuel.

In several situations limestone, of a coarse yellow or white colour, resembling chalk which will not mark, or of pale grey colour, hard and crystalline in fracture, is found. In some situations these beds are thick, and divided by sandstone, and in two places in Ramri they have been altered to dolomites, and contain minute grains of magnetite.

Speaking generally, the rocks in these islands have been much tossed and tilted, the dip being as a consequence irregular. Not unfrequently it is vertical, but owing to the softness of the sandstones and shales, and the absence of lithological characters, the disposition or lie of the rocks is often obscure.

In the absence of distinctive fossils or positive characters by which they may be identified, it is difficult to assign these rocks to any particular series or age. They are, however, in their general and salient characters, so similar to those further east, which we have next to consider, that I am inclined to relegate them to the same age.

Scattered over these islands are numbers of "salses," or mud volcanoes, some of which are subject to paroxysmal eruptions. At such times they discharge streams of salt mud, which, at Kyoukphoo, in Ramri, has a temperature of 92°. These mud volcanoes have a greater tendency to become disturbed during the rainy season than during the rest of the year; and this phenomenon has likewise been observed in similar districts in other parts of the world. These salses may be considered as the northern termination of the vast circle of eastern volcanoes stretching southwards by Barren Island, in the Bay of Bengal, all along Sumatra, Java, and the East Indian islands. Casuarina trees, which prefer a salt soil, surround these salses. It is probable that the ejected salt is derived from the rocks that yield the supply of mud. In the three Barongah islands in Ramri and Cheduba petroleum has for ages been known to exist.

In some parts along the coast hydro-carbons in a gaseous state escape under high-water mark, and can be lit on coming to the surface. Occasionally during violent eruptions of the salses or mud volcanoes, mud and stones are shot violently into the air, accompanied by large quantities of inflammable gas, and the gaseous emissions have, in some recent cases, caught fire from some cause,

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illuminating the country for many miles around. These violent eruptions are always synchronous or simultaneous with earthquakes that have passed over adjoining countries, and serve to illustrate the sympathy and connection which they have with the internal forces of nature. Similar emissions of gas has been observed in the mud volcanoes of Java, Baku on the Caspian, and near the Sea of Azof. When in a quiescent state bubbles of gaseous hydro-carbons issue from the vent. In Pathar, in Assam, a certain hollow contains many muddy pools in a constant state of activity, which throw out white mud mixed with petroleum.

The petroleum of Cheduba, Ramri, and the Barongahs, is of light specific gravity, is of mahogany brown or brandy-colour, contains a very large proportion of burning oil, and *almost no* solid paraffin. Oils possessing the same physical properties and chemical composition are found in the vicinity of long dormant mud volcanoes, in the Punjab and Baloochistan, and on the shores of the Red Sea, below Suez.

On the western islands of Burma the oil is collected in shallow holes or wells, and is periodically drawn off in Cheduba and the Barongahs. These holes are quite shallow, but in Ramri certain groups of wells have been sunk to a depth of from 20 to 30 feet before reaching the stratum from which the oil flows. As a rule, however, even in Ramri, they are mere surface pools, and in them only an insignificant quantity of oil is obtained, ranging from 2 to 50 bottles in a day. They are not evenly scattered over the surface of the ground, but are grouped together in those situations where the soil yields oil. The result of all my investigations has convinced me that, saving the appearance of the oil itself, there are no positive signs or indications by which an observing man could prognosticate, or determine, or fix on sites as those likely to yield a supply of oil. As will be afterwards pointed out, these oleaginous spots are eminently capricious and partial, and are determined by causes as yet unknown.

In the latter part of the year 1877 two English companies began the exploration of Barongah islands for petroleum. Convinced that the appearance of the hydro-carbons on the surface betrayed a deeper origin, and large reservoirs of oil in the depths, both companies resorted to boring. At the date of my arrival at Ackyab, in one case the bore-hole had reached a depth of 260 feet, having passed through successive beds of cherty sandstone and

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arenaceous shales or clays, containing calcareous nodules. Some of the beds were supposed to smell faintly of oil. In the other case two pits, 30 feet in diameter, had been sunk to a depth of 30 feet. In the bottom of each pit a bore-hole had been sunk. These bore-holes, on reaching a total depth of 68 feet from the surface, and after piercing a firm bed of calcareous clay, evidently struck a fissure containing pent-up gases. On being tapped, these gases rushed up the bore-hole with violence, and were followed by oil. About 500 gallons or so per day were drawn for the first week, after which it gradually diminished to insignificant proportions. This is the only instance within my own knowledge in which oil in these regions has been struck by a bore-hole and rose to the surface. In the case of the shallow native holes referred to the supply has existed for centuries, without, it is affirmed, any apparent or appreciable diminution. The supply may be taken, in short, to represent the rate of elaboration, or the rate at which the formative process goes on. In the case, however, of the slightly deeper wells, the yield, which at first is greater than in the surface pools, is, as a rule, liable to diminish, and in all cases where the depth of the wells is affected by the prevailing temperature, or are within climatic influences, the supply is intermittent, the yield in these cases being greatest just after the hot season and during the prevalence of the monsoon rains.

Turning our attention to the eastern extremity of this oleaginous zone of rocks within which earth-oils are found:—the country or districts to the east of the Arrakan mountains is wild, and innocent of roads. It has not been surveyed with any degree of accuracy. Although rocks of various ages may be supposed to occupy this great area, still, broadly considered, and from anything that I have observed, they may be referred to the nummulitic or Lower Eocene age, in parts giving place to Miocene deposits. In unravelling the geology of these remote regions one must be prepared to meet with many rocks and formations that differ widely from, and cannot easily be referred or correlated with, any of the typical rocks prevailing over the limited European areas, on the characters of which our geological treatises have for the most part been founded. And in many cases the explorer will do wisely to deal only with broad general principles in the absence of characteristic or distinguishing landmarks.

For some months I was engaged in investigating the capabilities

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of several oil-producing districts in the hot, and to some extent, wild country, bordering with Upper Burma, and stretching westwards from Thayetmyo. Thayetmyo (or Mango City) is a very formidable fort, surrounded by an extensive and picturesque "midan" or plain, which is studded at intervals with lovely mimosa and tamarind trees of patriarchal age. This plain is bounded by a succession of densely-wooded hills. The top of almost every eminence bristles with the tall, white, and graceful spires of pagodas; and, surrounding these, the dark, tapering, fantastic roofs of monasteries called "kyoungs," that add considerably to the natural charm and loveliness of the situation. The tops of the hills near Thayetmyo are composed of unstratified sands, enclosing irregular patches of water-rolled pebbles, and among these, over very large areas of the Irrawadi valley, are found the abundant remains of silicified forests in admirable preservation.

Proceeding westwards, over an extremely pretty but villanously rough country—covered with dense jungle, the shade of which, during the long hot season, can be compared to nothing more appropriate than an airless oven—these deposits give place to greenish or yellow sandstone containing no fossil remains, the bedding most obscure, and enclosing in parts large bullet-like nodules or masses of hard calcareous sandstone. The tops of the higher ridges are covered with laterite, or a brown earthy ferruginous mineral, often enclosing adventitious substances very similar in appearance to, though not so perfectly formed as limonite. So far as I am aware, the occurrence of laterite is entirely confined to the East Indies; and in some situations, such as Fort Canning, at Singapore, considerable hills appear to be almost entirely composed of it. These laterite ridges again give place to mottled red and yellowish sandstones, only partially bedded and coherent, and these sandstones rest upon light-grey or blue arenaceous shales or clays that contain many irregular calcareous concretions. These rocks are charged with large quantities of magnesia and lime, the former imparting to the water in wells properties purgative to the economy, especially of water-drinking Europeans—so much so that during all my residence in the district I was obliged to use only the water of the Irrawadi; and this had to be carried through the jungle a day's journey. Nearer the Arrakan range a few miles, similar beds to those I have described contain numbers of nummulites, some of which I exhibit; while some portions of the yellow

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mottled sandstones, as well as the harder masses of greenish arenaceous clays, contain numbers of shells, and some of these are also on the table for your inspection. Although my knowledge of conchology is limited, I take it that the character of these shells, or casts thereof, when taken in connection with the occurrence of nummulites, and the general character and appearance of the beds, point to an epoch or period not far removed from the Middle or Lower Eocene.

Originally the whole of this extensive district has been overlaid with these soft sandstone rocks, and these, I am inclined to believe, are, in parts at least, unconformable with the underlying beds. By exposure to climatic agencies, continued through a long period of time, these rocks have been worn and scooped out into innumerable ravines—an interminable succession or network of "nullahs" that are separated from one another by steep and narrow spurs. Where a few of these nullahs coalesce, a level part is formed of limited extent. The ravines are, as a rule, from 50 to 70 feet deep, and in the lower part the underlying clays are exposed. The whole country is covered by a dense jungle, consisting of taeping, acacia, jujube, and bamboo. The native villages that are scattered through the jungle are of small size, and are situated far apart. They are all, in this part of the country, surrounded by high and formidable stockades of bamboo, as a protection from the attacks of wild animals. The bridle-paths that connect these villages are extremely rough, and cannot be discovered without the aid of a native guide. They are too rough, difficult, and tortuous and hot to be recalled with complacency.

In a ravine or nullah such as I have just described, about 11 miles west from Thayetmyo, and within 1½ miles of a Burman village that rejoiced in the euphonious name of Pidoukbeng-Yua —called after a particular jungle tree that is abundant in the locality—appearances of earth-oil had some years previously been discovered. The nullah was thereupon called Yeynan Doon (or Earth-oil wells). Previous to my arrival, four wells had been sunk on the lower part of the steep slopes of the ravine, to a depth varying from 30 to 40 feet through the yellowish sandstones and arenaceous and calcareous clays, to a bed or stratum of greenish (when fresh), coarse, partially consolidated sand, on piercing into which the oil exuded in limited quantities. I will not inflict upon you wearisome particulars regarding its subsequent history, and

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the operations connected with the investigation, but will direct your attention to the sections, which represent almost 500 vertical feet of strata proved at this place, for every foot of which I possess samples. I think you will agree with me that the section bears out what I have already remarked, as to the general and prevailing lithological character of this district.

You will observe that there are at least three distinct beds of this greenish or yellow coarse sand at various depths, and which contain more or less oil, but always in small quantities. These beds are called by the Burmans "kabaas," and as this is an expressive name it has been adopted in the section. At Yeynan Doon the upper oil stratum or kabaa yields by far the greatest quantity of oil; indeed the yield of the lower seams was found to be insignificant. The oil is *only* contained in this porous coarse sandstone or sand, as in a sponge, and from it, when pierced, it slowly exudes—not, as in the case of the western islands, as a thin mahogany-coloured liquid, but as a thick, greenish-coloured one, containing a large percentage of solid paraffin, of pleasant smell, and entirely differing in physical and chemical properties from the product of the west coast. Its only point of resemblance lies in its being found under similar, or almost similar, conditions. You will observe that a firm layer of arenaceous clay, containing calcareous patches, overlies and underlies these kabaas—this clay being, in my opinion, almost impervious to the percolation of water. When brought to the surface it is perfectly dry. This circumstance, combined with the different properties of the oil, and the fact that it is *only* to be found in this soft, coarse, porous sand, early raised questions and speculations in my mind as to the origin of the product. I was well aware that the prevailing opinion of those who consider themselves qualified to form one, seems to incline towards the belief that mineral or natural oils have their source in the slow distillation of carbonaceous rocks by natural agencies deep within the crust of the earth. It is held by some that the American oils have had such an origin, but it is difficult to see in that case how they have come to occupy the position in which they are found, the position being far below the geological position of the beds from which they are supposed to have been derived. I had before me likewise the opinion of the Government geologist as to the origin of the oil of which I speak, his opinion being "that the lignitiferous beds are the true oil-

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producing as well as oil-bearing rocks." This, of course, assumes the existence of extensive deposits of lignite. At Cheduba, where oil for ages has been found, these lignites are in small nodules, at long intervals from each other, and are unchanged. So that in this case, if the lignites are the source from whence the Cheduba oil is obtained, they must exercise some catalytic action on gases or liquids, transforming them into hydro-carbons without, of course, being themselves changed. And this, I think, is out of the range of possibility. The yield of oil is continuous, and this of itself is sufficient warrant to relegate these haphazard opinions to the oblivion which they so deservedly merit. So far as I was able to determine, no carbonaceous beds exist in the neighbourhood or for many miles around. I pushed on the operations, not that I had any hope of discovering, as in America, enormous, or indeed any, reservoirs of oil, but mainly in the hope of obtaining some clue to work out the causation or production of these earth-oils. To prove the extent and continuity of the oil kabaas, I put down a line of bores along the ravine (see plan), and proved these again by sinking small pits, with the result that the deposit was clearly proven to be of very partial and circumscribed area. Beyond these limits I traced the same kabaa a little thinner, and not possessing such well-marked characters, but in true position. The clays above and below were more arenaceous and less calcareous, but the kabaa was entirely devoid of all trace of oil. In its stead, however, and probably to compensate for its absence, the kabaa gave off an abundant supply of water, highly charged with sulphuretted hydrogen gas. The capricious nature and the limited extent of the deposit greatly added to my perplexity as to the cause of these oils. An examination of the nullahs showed no sign of faults or dislocations of the strata. The temperature of the oil drawn from the bottom of the deepest or exploring well—126·0 deep—was 88°, or considerably under the daily temperature of the deepest shade prevailing during nine months in the year.

During this period many reports were brought to me by natives of the occurrence of petroleum in surrounding districts. Every one of these I visited—some of them being situated among the main spurs of the Arrakan mountains, two days' journey on horseback, in a wild and little-known country, among half-civilized tribes, the faces of whose women were deformed by profuse tatoo-

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ing to prevent their being stolen by predatory bands from adjoining tribes with whom they might be at feud. The invariable result in almost every instance was, that I found distinct but insignificant traces of petroleum exuding from rocks of similar character to those that I have described. A small patch of such a rock was found to be soaked with oil. The appearance of this patch conveyed the impression that the source of the oil was from a spot in the underlying calcareous clay; but which I was never able to discover. The cause of this may only become apparent when some real clue has been found wherewith to unravel the mystery connected with the formation of the oil itself.

Returning for a moment to Yeynan Doon wells: after the first monsoon rains had fallen, the yield of oil from the top kabaa greatly increased in amount; and this increase was *not* accompanied by any increase of water. The amount of this increase varied in the different wells from three to six times more than that drawn during the dry, overpowering heat of the hottest months.

For the purpose of obtaining some information that might be turned to good account in my investigations in Lower Burma, I determined, after making careful inquiries, to proceed to Upper Burma, and trust to the fates and good luck to be enabled to inspect the king's wells, which for centuries have yielded very large quantities of oil.

Naturally the scenery of such a great river as the Irrawadi varies considerably. For the most parts the banks are bold and picturesque. After passing through the monotonously flat and fertile plains of Pegu, spurs from the Arrakan and Pegu ranges approach each other, and in several places confine the river within a comparatively narrow channel. In the valleys between these spurs the channel during the hot season is simply a deep ditch, from 1 to 1½ miles wide, enclosed by steep banks of alluvium from 40 to 45 feet deep. In these situations the river is continually changing its route—and very trivial causes are sufficient to bring this about—wandering from side to side, cutting down the soft banks, and removing incalculable quantities of *débris*, to be deposited as banks further down the river to endanger navigation, or, if muddy, to be carried to the delta, there to add to the ever-increasing coastline, and to the fertile areas of British territory. The naturally unique and impressive singularity of the scene is enhanced by the

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innumerable graceful, glittering spires of pagodas, and the quaint, tapering, carved roofs of rest-houses that cap every eminence, embosomed amid the quivering fronds of palms. Fantastically carved boats with enormous balloon-like sails add also to the general effect. On leaving Thayetmyo, the steamer passes slowly against the stream through a mountainous country, and in about six hours stops for a pass at the frontier station of Menhla, belonging to the "lord of all the umbrella wearing chiefs," of "many white elephants," "king of kings of many kingdoms," "the great king of righteousness," to wit, King Theebaw. Beyond this the hills recede into the blue distance, and the river winds through an undulating and fertile country. At Magway, where a large silicified forest is exposed in the river bank, the fertility disappears and gives place to a desolate region, consisting, on one side of the river, of glowing, bare sandstone hills, covering light-coloured shales or fire-clays containing many accessory blocks. After many hours steaming through this burning, desolate region, a dark mass of foliage and many glittering spires are seen—an oasis among the yellow sandstone hills. The quaint beauty of the spot rivets the attention. A great pagoda rises, terrace above terrace, out of the shimmering waters, and a town occupies the face of a hill. The hollow is a black mass of luxuriant foliage that speaks of an "endless continuity of shade." As we approach, the smell of petroleum fills the air. A fleet of cargo boats load it in bulk; acres of great earthern jars containing it line the beach. This is Yeynan "choung" (Earth-oil creek) the shipping place of the oil drawn from the king's wells, that are situated a few miles inland, and reached by an all but impassable track. Beyond the limited but extremely picturesque patch of fertility that surrounds the town, a region of perfect sterility stretches as far as the eye can reach, and here we live a rough and ever-watchful life within the high stockade of the Indian Mahomedan, who farms from the king the whole produce of the wells.

Below the landing place the river is bounded by cliffs of soft mottled sandstone, probably 100 feet in height. These rest upon beds of firm clays, containing irregular patches of hard calcareous jagged ridges that run out into the great river—here fully a mile wide. The tops of the higher cliffs and the adjoining conical hills are capped with laterite overlying the remains of silicified trees. And from the top of these eminences the eye scans to the north

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and east a rolling sea of desolate, glowing sandstone hills without a vestige of vegetation, over which the heat quivers in the air, and the fervid sun dazzles with a fierce delight.

We ride out of the delightful shade of the luxuriant oasis, that surrounds the landing place, and its numerous ancient shrines, into the forbidding desolation and the parching heat of these sandstone rocks. At the river the strata have a strike approaching S.E. and N.W. At first the beds lie irregularly, but generally at a high angle—sometimes in faulted ground they are tilted almost on edge. The rocks, so far as I could discover, are non-fossiliferous, and are composed of soft variegated sandstone, traversed in parts by strings of talc and calcspar, and enclosing accessory blocks of hard flinty masses of waterworn sandstone, or grey sandy clays, the whole cut and worn into fantastic shapes, bounded by ravines very steep, and of irregular outline. The sandstones are redder and much thicker than near Thayetmyo. The rough path leads almost directly to the rise of the strata, and as we proceed the rocks gradually approach the horizontal. We pass over the lines of two or three faults, beyond which the obscurely-bedded rocks are seen to flatten, and then gradually to take a reverse dip; and presently we halt to breathe the superheated air "under the shadow of a great rock in a weary land," and to look down upon the famous Tongune oil-wells of "the master of many white elephants," and the "great king of righteousness." These wells number about 800, occupying the top of a broad ridge between two parallel ravines. The space over which they are scattered is oblong, and does not exceed 500 acres in extent. If you refer to the sketch plan, in which I have endeavoured to portray the distribution of these wells, you will observe that the area over which they are placed is strictly defined. The oil stratum is partial, and entirely confined to this area. Why it should be so is not so clear. It was affirmed by many natives who had been employed all their lives here, that the area under which oil is found does not cross, but is bounded strictly to the course of, the two ravines, to the east and west, and to the north and south by a line of wells more or less straight, but beyond which *no* oil is found. The ravines to the east and west are about 60 feet deep, with all but perpendicular sides, and wells are sunk all along the inner cliffs and yield large quantities of oil. On the opposite cliffs, perhaps 50 or 60 feet longitudinally from these working wells, the remains of several old

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wells are seen. These wells were sunk to the kabaa, but it gave out *no* oil. Certain it is, not a single well exists beyond the centre line of these choungs or ravines. The rocks appear perfectly regular on the two sides. To the north and south a few abandoned wells are also seen on the surface. These had been sunk in the expectation of proving a continuation of the oil kabaa. They did prove its continuity, but it was thinner and of harder consistency, and instead of oil it gave off water. A careful examination of the rocks exposed in the ravines disclosed the fact that the course of the arbitrary line that determined the oil-yielding kabaa to the N. almost corresponded with the course of a very slight anticlinal (shown on the plan in the horizontal section), while to the S. the change of dip marked the boundary in that direction. As I have remarked, an examination of the ravines threw no light whatever on the reason why the oil should be limited and confined towards the E. and W. by the artificial line of two gorges evidently formed by the long-continued operation of natural causes. Towards the S.E. corner (at D on plan) a few small patches of oil were seen soaking the sandstone at the bottom of the cliff. These were quite partial, and are confined to the areas in which they are exposed; as in the wells sunk from the cliffs above, and within a few yards longitudinally, not the slightest trace of these pockets of oil-sand was observed.

Altogether, over the uneven surface of the square mile under which this deposit extends, there are over 1000 wells. Of these, it is affirmed about 800 are capable of yielding oil, although at the present moment, from the lessened demand in British Burma, consequent on the large importation of the American product, and also from the state of disrepair in which many of the wells are, not more than 280 wells are being worked. Roughly speaking, the largest number of wells are grouped along the margins of the choungs or ravines, and the largest number of abandoned wells occupy the centre or top of the broad ridge. Indeed, there is a considerable area of ground here, where no wells, and few vestiges of wells exist. All these wells have been sunk to one of *two* oil kabaas that are known to exist. The principal of these is the upper, which appears to overlie the other only by a few yards. It is believed (and I think the natives are justified in so believing) that, if all the abandoned wells were cleaned out and resunk, they would again become oil-

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yielding wells. This, however, even with appliances for producing ventilation, would be a difficult operation, as from the abundant gases given off no lights can approach a yielding well. All operations such as sinking are at present conducted in total darkness, a workman not being able to remain in the bottom more than two to three minutes, and being then drawn up limp and quite exhausted. The working wells, for the reasons stated, are not wrought to their full extent. Within the oil district these wells do not yield a drop of water. A few yards, however, beyond the arbitrary boundary line, wells sunk to the position give off an abundant supply, and, as a rule, the water is charged with hydrogen gas. The oil stratum is about five feet thick. Its composition, as you will observe from the specimens before you, is loose and incoherent. It is highly charged with oil, which oozes out whenever a fresh lump is placed in the ground. In a few wells only thin and insignificant strings of carbonaceous matter are seen as irregular streaks, and precisely similar appearances may be observed in any sandstone quarry. A few irregular pockets of lignite are also got in one or two of the wells in a sandstone many feet above the kabaa.

When the oil kabaa is pierced, gas and oil issue freely, but with no force or pressure. They exude as water does out of a freshly-charged sponge—by gravity. The oil never rises more than a few feet. If a group of wells, closely placed in relation to each other, are worked simultaneously, the yield from each well is appreciably less than if one-half of these were stopped. For this reason the drawing wells are now spaced about 40 yards apart. It commonly happens that among a group, one or two wells yield a far larger supply of oil than those adjoining, and this without any apparent reason. No two wells, although the conditions are, to all appearance, identical, yield equal quantities. The production varies from 5 to 1,000 "vis" per day per well—a vis is equal to fully $\frac{1}{3}$-gallon—so that the yield from these wells varies from 2 to 400 gallons per day. Some wells have yielded from 500 to 700 gallons per day, for the first three years, surrounded by other wells that did not give quarter of that quantity. A well was specially pointed out to me that had yielded 700 gallons per day for a number of years, after which the supply diminished gradually, until it reached 130 gallons, and for the last eighteen years it has given off that quantity only. The tendency of all wells, if drawn to their full production, is to slightly diminish

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their yield of oil, though at these wells this appears to be a very gradual process. When a well first taps the oil kabaa, the emanation of vapour is overpowering. So great is it that the workmen can only with great difficulty pierce, say a foot, into it. In process of time, when the yield of such a well decreases sensibly, it is cleaned out, and resunk a foot or two further; fresh kabaa is thus opened up, and the supply again increases in amount.

The depths of these wells vary with the surface level, and the dip or rise of the strata. In the division marked C on plan, the average depth will be about 320 feet. Near to the centre some wells, at present closed, were said to be upwards of 400 feet. At B, from the surface level, and rise of the kabaa, they will not average more than 200 feet, decreasing towards the east to 120 feet or so. The larger marks on the plan designate the wells that give the largest yield; but how one well, surrounded by twenty or thirty others, should thus give five or six times more oil than the adjoining wells, will, I think, only be explained in a satisfactory manner when a clue has been discovered to reasonably account for the production of the oil itself. The oil drawn from these wells is of three qualities—samples of each are before you. No. 1 is called Yeynan Ghee, or butter of oil; 2nd, Umbaron; 3rd, Kyathee. All of them are of a dark green colour, thick and viscid in consistency; when kept for some time at a temperature of 60° or under, they get almost solid. The odour is pleasant, and not strong. The specific gravity is about ·810, and the temperature of the newly drawn oil is about 88°, or 26° under the temperature in the shade during my visit. It differs from the American product or that of the west coast in containing a very large proportion of solid paraffin. It gives about 71 per cent. of burning oil, the rest being lubricating oil. The flashing point of this oil is about 20° higher than the American, and in every respect it is a superior and more valuable product. At the time of my visit (16 months ago) the quantity of oil drawn from these wells was 6000 gallons per day, but this, I was assured, was scarcely one half of what the wells could produce.

About three miles to the south of Tongune wells there is another small patch of rugged ground called Bhaema, as bleak and forsaken in its desolation as the former, and which from very ancient times has yielded oil under precisely similar conditions. The intervening country is much too rough to travel over. We

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approached it from Yeynan choung on the Irrawadi, the path being along the course of a torrent on which rocks and boulders are piled about in chaotic confusion. Then it leads over a rugged expanse of bare rocks, and which, from an inclination of 36°, gradually flatten. Then we cross the line of several east and west faults, after which the beds dip towards the north, and beyond this oil-wells are sunk. You will observe from the sketch plan that the main ravine bifurcates, one branch running north, the other to the south. The wells are grouped along the irregular sides of these ravines, and for some little distance up the steep sides of the hills. The area over which the wells are scattered will probably not exceed 180 acres. Towards the north the limit of the wells is sharply defined by the course of a well-marked anticlinal, exposed in the cliffs to the east and west, exactly in the same manner as at Tongune wells. Towards the east and west the native sinkers consider that oil would be found if wells were sunk, but these, from the nature of the ground, would necessarily be of great depth—too deep and expensive to be thought of by an impecunious monarch whose career is likely to be cut short by the aggressive policy of Britain. How sharply defined the area is within which oil is found is clearly seen at Bhaema. If you refer to the sketch plan of these wells you will observe the course of the anticlinal marked by a succession of black bars running east and west. At the north-west corner wells yielding nothing but oil are sunk up to the point A. At that point a well—indicated by a circle—was sunk, almost exactly on the anticlinal, to the kabaa, and gave a good supply of oil for years. Some years ago it was determined to increase this supply by piercing the oil-sand a foot or two deeper. This was done, but in sinking the two feet a feeder of water was struck, and this well ever since has given off about 200 gallons daily, half of which is water. A few yards towards the north—beyond the anticlinal—two other wells have been sunk, but were abandoned on their giving off nothing but water. This, so far as it goes, is pretty clear evidence that an anticlinal ridge may define the area of distribution of earth-oils. I have subsequently learned that similar phenomena have been observed in America.

The cliffs exposed at Bhaema illustrate how very irregular and capricious these sandstone deposits are. The section [Plate VII.] taken from one of these, shows wedges or islands of calcareous

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sandstone, and this may partly explain the capricious nature of the kabaa itself. No deposit is so uncertain, even over limited areas, as sandstone. The sandstone that caps the higher ridges appears to lie unconformably to the underlying shales, and this I had previously suspected to be the case in Lower Burma. Thin veins or strings of gypsum or selenite penetrate these rocks.

The number of wells at Bhaema exceeds two hundred. They are very old. Some of them are out of repair; others are not at present wrought, or are worked to their full capacity. From the eighty that were working at the date of my visit, about 2,200 gallons per day were drawn, equal to an average of 28 gallons for each well. The depth of these wells average 220 feet. The yield of oil has almost always exceeded the demand. The quantity is not liable to any appreciable variation. The specific gravity at 60° is ·820. The temperature when drawn is 88°. The King's agent at this place—a most intelligent man—informed me that the wells, when fully drawn for a considerable time, slightly diminish in production, but that the original quantity always returns again after a short period of quiescence, on diminishing the quantity drawn daily. The strata appear to be identical with those at the adjoining wells of Tongune. In a few of the west wells a layer of dolomite 14 inches thick is passed through, opposing all but an insuperable obstacle to the sinkers, armed as they are by the one primitive sinking tool (called a "tayuen") with which they are provided—consisting of a small chisel, into the hole or socket of which is inserted a large tapering chip of wood to give impetus to the blow. These wells are all of one size—viz., 3 ft. 9 in. square—perfectly plumb, and the sides secured by rude planks 6 in. broad by 1½ in. thick, notched into each other in a most unscientific manner. The oil is drawn to the surface by means of an earthen pot, to the neck of which a rope is attached. This runs round a small wooden roller attached to a frame-work of props. Three or four men or women are required to overcome the friction and the weight. They catch the rope over their shoulders and run outwards over the uneven surface of the ground. Men are raised or lowered in the same manner. One leg is passed through a large noose, while the body is tied to the rope to prevent the man from slipping off, should he become insensible from the effects of gases or vitiated air. To raise a man from such a depth 10 to 14 men are required; and as a sinker can seldom

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remain in the bottom over three minutes, you can form some idea of the difficult and laborious process it is to sink a deep well, especially when gas exudes from the higher strata.

Probably not more than 100 of the 1300 wells of Tongune and Bhaema actually belong to the king; the remainder were sunk, and are wrought, by villagers. Some years ago, however, when the demand for paraffin and petroleum arose, the king, standing upon the prerogative of a despot, suddenly monopolised the sale of the whole produce—that is to say, he stopped the owners of the wells from selling an ounce of their own oil, binding them to deliver the whole supply to his agent, and taking good care to fix the price at a quarter of that which he obtained for the produce. As the price has risen greatly, the owners of the wells might yet do fairly well, but the king only promises to pay them, and seldom fulfils his covenant.

About thirty miles higher up the river, and ten miles inland, there is another small group of wells, the product of which is almost identical in colour and properties with that of the western isles before referred to. On account of the special interest that the "woon," or head-man, had latterly taken in our movements, and the espionage to which we were in consequence subjected, we considered it expedient not to visit these last-named wells. I can therefore do no more than record the circumstance that such wells exist. I have formerly mentioned that in Java, on the shores of the Caspian Sea, on the shores of the Red Sea, in Baloochistan, and in Assam, where there are active or passive salses, petroleum of a light specific gravity, of a mahogany colour, containing almost no solid paraffin, is found, and in circumstances identical with that found in Ramri and Barongah, and specimens of some of these are before you. These oils, however, differ widely in character and appearance from the more abundant and valuable product of Thayetmyo and the king's wells. Closely resembling the latter is the oil from a partial area of cretaceous rock in Slesvig Holstein. Highly impregnated with oil in many layers down to a depth of 200 feet, loose bands of porous sand are found, every one of which is charged with petroleum, the origin of which is unknown. In Brunei territory in Borneo petroleum is found in similar circumstances, and the natives collect the oil in shallow holes. In Japan, to the north-east of Tokio, oil of a similar character to that from the king's wells

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is found, and 300 years ago it was conducted into houses by means of bamboos, and used for lighting. At the present moment the Japanese have sunk 500 wells to depths varying from 400 to 600 feet. The produce is insignificant, averaging only 1½ gallons per day from each well.

You are probably aware that there is a prevailing opinion that the enormous reservoirs of oil found in Canada and the United States have resulted from the slow distillation of the great anthracite coal-beds and accompanying shales, and that the oil so formed has thereupon percolated through strata to occupy cavities in rocks of Silurian and Devonian age, far removed from the supposed place of origin. This theory I confess I cannot readily follow. The American oils are similar to the oils of the Punjab and the Barongahs, and probably owe their origin to a similar cause. A different theory is probably necessary to account for the altogether different product of Thayetmyo and Upper Burma. Probably every separate deposit owes its origin to a distinct and specific cause. In other words, it is probable that no two deposits may be traced to a similar cause or source. Still, in my own mind, in the absence of a satisfactory theory to account for their production, I am satisfied that the source of these earth-oils is not to be found in the distillation of lignitiferous deposits. I can readily see how a small and localised deposit of sandstone may be soaked and infiltrated by oil produced by the slow distillation of contiguous bituminous beds; and, in point of fact, I am aware of several black sandstones that have been so infiltrated through a limited space, and changed in colour by subsequent metamorphosis, but that is not the source of Burmese oil, where the necessary factors are awanting. These native oils are very widely distributed over the surface of the earth, in Italy, Russia, Persia, India, Java, West Indies, Peru, Japan, and the United States. While in some of these countries earth-oils are found in rocks older than those belonging to the true Carboniferous age, the majority occur in rocks of Miocene or Tertiary age, and very few, if any, occur in those of Carboniferous age, precisely where one might expect them if their source is really in the distillation of carbonaceous deposits. At the present moment I am inclined to think that the source of these earth-oils, taking them in the concrete, may be due to the operation of forces, or the result of some purely chemical reaction

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perfectly localised, and confined to the areas under which oil is found, and that these are in continual operation, elaborating the oil from hour to hour, and from day to day, at a constant and regular rate of production.

Taking the yield of the king's wells, and the cubic contents of the kabaa—I will not read you the details—and assuming that the porous kabaa can absorb $\frac{1}{4}$, or 25 per cent., of its total bulk of oil, it follows that this kabaa would be entirely drained of every vestige of its contained oil in 33 years.* But, as these wells have been in operation for some centuries, one is, I think, safe in assuming that this sandstone has probably given off ten times all the oil contained at one time, or oil equal to the total bulk of the kabaa twice or three times over, and is yet as prolific as ever.

The source from whence these hydrocarbons are derived, that permeate into, and are absorbed, and mechanically held in this porous sandstone? The reason why they are confined strictly to limited areas, and equally penetrate almost every spot, not only of the bottom, but of the sloping sides of a basin or trough? Why is water only given off beyond the limits of these boundaries? These are questions well worthy the attention and the careful investigation of the many experienced and eminently scientific members of this Society. Traditions as to the discovery of petroleum in Upper Burma, and the causes which induced the observing people "of that ilk" to penetrate to such depths in search thereof, are somewhat obscure and unreliable. Are they not, however, written in the chronicles of the ancient pagoda-building chiefs, which, in the distant past, became enveloped in the obscurity of that shadowy river that flows for ever and for ever towards the shoreless sea.

* Calculation referred to. Daily produce of oil, 25,000 vis (100 vis = 40 galls.) = 10,000 galls.; 1,600 cub. ft. or 60 cub. yards of oil per day = per year 21,900 cub. yards; actual extent over which kabaa extends, say, 400 acres averaging $4\frac{1}{2}$ ft. thick = 2,904,000 cub. yards, 25 per cent. of which is 726,000 cub. yards ÷ 21,900 cub. yards = 33 years.

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XXXIII.—*On a* Series *of* Foraminifera *and* Ostracoda *from a* Post-tertiary Deposit *in* Lewis. By David Robertson, F.L.S., F.G.S.

Last summer my wife and I spent a couple of weeks in the Outer Hebrides, and had a few pleasant explorations among the lochs and tarns for fresh-water Ostracoda. At Lewis there is a small grassy streamlet, issuing from a gravel quarry on a high ridge on the wayside, between Stornoway and Barvas.

There was very little water in the streamlet, not more than covered the short grassy vegetation, giving little hope of much success in the way of fresh-water Ostracoda, and for this reason no great effort was made. Judging from the contour line on the map, the quarry cannot be less than between 300 and 400 feet above the level of the sea. None of the material collected was examined till our return home, when, on looking over this gathering from the gravel quarry, it was found to contain marine Foraminifera, Ostracoda, and Star-fish plates.

Had there been only one or two of these organisms, they would have been thrown aside as having got there by accident, except there had been strong proof to the contrary; for it does happen sometimes, notwithstanding all the care that can be taken, that such waifs will make their appearance. When we take into account, however, the large number of different species obtained, there can be no room left for doubt that they are from a marine deposit. Had these forms been seen before leaving Lewis the true position and character of the deposit might have been ascertained. It is most probable that the gravel rests on the marine clay that contains the Foraminifera, which would be taken up by the net in the mud at the bottom of the sluggish streamlet, whose scanty water seemed to be supplied only from the rain that fell in the trough of the quarry, together with that which oozed out of the gravel, so that they could not be brought from any more distant source.

The following are the species obtained, and they are all similar to those obtained in the clays of the Clyde valley:—

Foraminifera.

Triloculina oblonga.	Mont.	*Lagena marginata.*	W. & J.
Lagena Williamsoni.	Alcock.	,, *squamosa.*	Mont.
,, *sulcata*, var. *interrupta.*	Will.	*Orbulina universa.*	D'Orb.

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FORAMINIFERA—*Continued.*

Globigerina bulloides. D'Orb.
Textularia pygmæa. D'Orb.
,, *sagittula.* Defrance.
,, *variabilis.* Will.
Verneuilina polystropha. Reuss.
Bulimina marginata. D'Orb.
,, *aculeata.* D'Orb.
,, *pupoides.* D'Orb.
,, *ovata.* D'Orb.
,, *elegantissima.* D'Orb.
Virgulina Schreibersii. Czjzek.
Bolivina plicata. D'Orb.
Discorbina rosacea. D'Orb.
,, *Parisiensis.* D'Orb.
Truncatulina lobatula. Walker.
Pulvinulina. Sp.
Rotalia nitida. Will.
Polystomella crispa. Linn.
,, *striato-punctata.* F. & M.
Nonionina depressula. W. & J.

OSTRACODA.

Cythere tuberculata. G. O. Sars.
,, *convexa.* Baird.
Cythere villosa. G. O. Sars.
Laxoconcha impressa. Baird.

Also one plate of a Star-fish.

The great number of these organisms here obtained, in not more than three or four ounces of material, was much more than usually occurs in the same amount of material from Post-tertiary deposits. It is not unlikely, however, that numbers of these minute objects might be washed out of the same clay, and be carried down by the water that trickled from the bottom of the quarry, and be intercepted among the grassy plants where they were found. The chief interest in the discovery of these Foraminifera is the great elevation at which they were met with. With the exception of the Post-tertiary bed at Chapelhall, this at Lewis is the highest in Scotland. These fossiliferous clays are not unfrequently met with on various parts of the island. The greatest altitude of these patches given by Dr. James Geikie in his paper on the Glacial Phenomena of the Long Island or Outer Hebrides in the *Quarterly Journal* of the Geol. Soc. for Nov., 1878, p. 827, is that of one patch at 175 feet above the sea level.*

As a greater interest is beginning to be taken amongst geologists in the superficial deposits of our country, there is every reason to believe that many discoveries of fossiliferous deposits will be made before many years pass.

We may reasonably assume that if a careful search were made for fossil-bearing clays they would be found in places where they

* Since the above was written, Mr. James Fraser, C.E., Inverness, has discovered a clay deposit containing arctic shells at Clava, in the valley of the Nairn, at an elevation of 500 feet above the level of the sea.

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never had been suspected. The most of our fossiliferous deposits have been brought under notice by the presence of shells, but it is not an unusual occurrence to find Foraminifera and other minute organisms in laminated clays that contain no shells. We may travel over mountain and dale without being attracted to a single deposit by the appearance of a shell, although we may have trodden over not a few fossiliferous clays. In all laminated clays or mud-beds laid down by water there is a chance, a probability, that they contain organisms which would throw light on the character of the deposit.

XXXIV.—Classification *of the* Carboniferous Rocks *of* Scotland. Reply *to* "Remarks, &c.," *by* Mr. John Young, F.G.S. By Prof. Hull, LL.D., F.R.S., &c., Director of H. M. Geological Survey of Ireland.*

[Read 11th March, 1880.]

I have just received vol. vi., part i., of the *Transactions* of this Society, containing the "Remarks" on my paper "On the upper limit of the essentially marine beds of the Carboniferous system of the British Isles, &c.,"† by my esteemed friend, Mr. Young. Any criticism on the views I have put forward, by one so competent to form a judgment as he is, I gladly welcome; but on reading his paper it appears to me that he has passed judgment upon the subject from reading the "Abstract"—which was published immediately after my paper was read before the Geological Society—rather than from the paper itself. I gather this, both from the tenor of Mr. Young's criticism and also from the foot-note to the effect that my paper "*has since been printed in full*"—that is, since Mr. Young's notes were drawn up. I do not at all complain of this; but it will be clear that an author's views can never be clearly or fully explained within the limits of a brief abstract of the original paper in which the details are embodied. Hence it seems to me that my reviewer has formed a misconception of the matter contained in the paper itself; and, in replying, I shall confine my observations as far as possible to the Scottish Carboniferous area, which Mr. Young has done so much to elucidate.

Admitting fully, with Mr. Young, that the physical conditions,

* See *Transactions*, vol. vi., part v., p. 26.

† *Quart. Journ. Geol. Soc.*, Nov., 1877, p. 613.

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under which the strata of the same period in the Carboniferous area were deposited, vary much in different countries, and that the conditions in Scotland, being generally more of a marginal character than those in England, must present some differences as compared with the English beds, yet, I must ask my reviewer to take a wider survey than that immediately under his scan, and on looking over the list of marine genera and species recognised in stage E (Gannister beds),* which are not known to pass upwards into stages F or G (Middle or Upper Coal-measures), to ask himself whether there is not a remarkable palæontological change clearly shown by this census.

This stage E (Gannister beds) I have identified in Scotland with the "slaty black-band ironstone," and out of its 36 genera and 70 species of marine forms, only 6 species are known to ascend into stages E and F, and their occurrence is quite exceptional in the British Islands.

Mr. Young speaks of the "fresh-water strata of our Carboniferous limestone series," by which I presume he refers to the "Lower Coal and Ironstone Series of Scotland," but on reference to my paper (p. 634), it will be seen that I refer this group to the "Yoredale Beds" (stage C), and not (as hitherto supposed) to the stage of the true Carboniferous limestone (stage B), which is everywhere of marine origin. That there may be estuarine beds in stage C in Scotland I do not deny, but, supposing this to be proved, it does not invalidate my statement that stages C, D, and E are "*essentially marine.*"

With reference to the evidence of conditions of deposition to be deduced from the remains of ganoid fishes, or of molluscs of the genus *Anthracosia*, I have adduced evidence to show that the fish were migratory in their habits, frequenting both lakes, estuaries, and the open seas of the Carboniferous period, and that the bivalves of the genus referred to are equally unsatisfactory as evidence of the conditions under which the strata were deposited.

In the case of stages A and B, which include the Calciferous Sandstone Series and Burdiehouse limestone, I have called them "essentially marine (except stage A in Scotland)." This exception was made in consequence of the fauna of the Burdiehouse limestone being generally considered to indicate fresh-water con-

* Table II., in original paper.

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TABLE OF REPRESENTATIVE

	Stages.	England and Wales.		Ire-
		North.	South.	North.
Upper.	G.	Upper Coal-measures of Manchester, &c., Staffordshire, Denbighshire.	Generally absent (through denudation).	Absent (through denudation).
	F.	Middle Coal-measures, with thick coal-seams, &c., Lancashire, Yorkshire, Derbyshire, &c.	Middle Coal-measures of South Wales and Somersetshire, &c.	Coal-Island Coal-field, co. Tyrone.
Middle.	E.	"Gannister Beds," or Lower Coal-measures.	Lower Coal-measures, with ironstones and thin coals.	Lower Coal-measures of Drumglas (Tyrone), coal-fields of Lough Allen (co. Leitrim).
	D.	Millstone Grit series, Lancashire, Yorkshire, Derbyshire, &c.	Millstone Grit, or "Farewell Rock."	Millstone Grit of Fermanagh, Sligo, &c. (Cuilcagh).
	C.	Yoredale series, or Upper Limestone shale. "Upper Bernician beds" (Lebour).	Upper Limestone shale (thin).	Ironstone shales of Lough Allen, also of Drumglas (co. Tyrone).
Lower.	B.	"Mountain Limestone" of Derbyshire, "Scaur or Scar" Limestone (Sedgwick).	Carboniferous Limestone of Cheddar, the Wye, Avon, and S. Wales, &c.	Carboniferous Limestone in three divisions. Ballycastle Coal-field, co. Antrim (in part).
	A.	"Tuedian Group" (Tate), often absent in N. Lancashire, &c.	Lower Limestone shale (thin).	Calciferous Sandstone series or Lower Carboniferous Grits.

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CARBONIFEROUS FORMATIONS.

LAND.	SCOTLAND.	CONTINENTAL.	Conditions of Deposition.
South.	Central.	Belgium and Germany.	
Absent (through denudation). Leinster Coal-field, from the "Jarrow Coal" upwards.	Upper red sandstones of Bothwell, &c. Ayrshire beds with Spirobis Limestone. "Flat-coal series" or "Upper coal series" of Scotland, with thick coals.	Possibly present in the Belgian and Saarbrück Coal-fields. Main Coal-measures of Belgium, Saarbrück, Westphalia, Saxony, and Silesia, &c.	Essentially estuarine and lacustrine, with intrusions of the sea at long intervals.
Lower Coal-measures of Leinster, Modubeagh, Tollerton, Skehana and Slieveardagh, &c. Flagstone series of Carlow, Kilkenny, Clare, &c. "Shale series" of Carlow, Kilkenny, Clare, &c.	Beds on the horizon of the "Slaty-band" ironstone? "Moorstone rock" and Roslin sandstone. "Upper Limestone series" resting on "Lower coal and ironstone series"?	Schists de Lens, Auchy-au-Bois, Chokier. Bottom shales of the Coal-measures of Silesia, &c. Absent in Belgium. Flötzleerer Sandstein of Germany. Absent in Belgium.	Essentially marine, rarely estuarine. (Sea shallower than in Stage B.)
Carboniferous Limestone, in three divisions. Lower Carboniferous slate (in part) with Coomhola grits.	"Lower Limestone series" of Gilmerton, Roman camp, &c. Calciferous Sandstone series in two groups.	Carboniferous Limestone of Belgium (Calc. de Dinant, Calc. de Tournai), France, Germany, Russia, &c. "Schistes de Tournai," and "Kiesel-Schiefer," &c. "Jüngere Grauwacke" of the Vosges and of the Schwarzwald.	Essentially marine, and deep-sea beds (except occasionally in Scotland, where lacustrine or estuarine beds occur).

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ditions; but Mr. R. Etheridge, jun., has recently shown that several beds of marine invertebrata occur throughout the lower Calciferous sandstone series,* showing that the formation is in the main of marine origin.

Having thus replied to the objections of Mr. Young, I ask permission to reproduce from my paper Table II., giving a synopsis of the representative strata—over the whole area I have included in my remarks—for the convenience of those members of the Society who may not easily have access to the *Quarterly Journal* of the Geological Society of London; and I would venture to suggest to Mr. Young that it meets the desire expressed in the last sentences of his "Remarks."

XXXV.—Notes *on the* Hohentwiel, *a* Volcanic Cone *in the* South *of* Wurtemberg. By J. C. Christie.

[Read 11th March, 1880.]

Although belonging to the kingdom of Wurtemberg, the remarkable cone known as the Hohentwiel, with the ruined fortress on its summit, and a narrow fringe of land around its base, stands in, and is entirely surrounded by, the territory of the grand duchy of Baden. It is about two miles N.W. of Singen, which lies in the very south of Baden, only a few miles N.W. of Constance, on the lake of the same name, otherwise known as the Boden See, of which on a clear day it commands a splendid view, extending as far as the Tyrolese Alps in the S.E., and the Bernese Oberland and Mont Blanc in the S.W. As the railway which leads from Constance to Schaffhausen affords a passing glimpse of the imposing grandeur of the Hohentwiel, the progress of thousands of travellers is yearly arrested, and they alight at Singen to pay a flying visit to the highly-picturesque peak, crowned by its extensive and venerable fortress, now in ruins for 80 years. The interest which it excites is not of modern date, for the visitors' book contains entries from 1652 to 1799, recording the visits of princes, dukes, barons, counts, and courtiers without number, some of whose descendants have attained a world-wide celebrity, for we find here the autograph of Jean Adolph Baron de Kielmans Egge, whose name has been rendered immortal in Hood's poem, "Miss Kil-

* *Quart. Journ. Geol. Soc.*, vol. xxxiv., p. 1.

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mansegg." The Baron seems to have been a student of both nature and human nature, for he writes above his signature that

> "Femme, Vent et Fortune
> Se changent comme la Lune."

The summit of the rock is about 2,300 feet above sea-level, and about 856 feet above the small river Aach, which flows past its base towards Singen. The surrounding level district, called Höhgau, or Hegau, is remarkable for its group of volcanic cones, known respectively as the Hohentwiel, Hohenkrähen, Staufen, and Mägdeberg—(Phonolith)—Hewenegg, Hohenstoffeln, Hohenhewen and Neuhewen—(Basalt)—besides a few smaller ones less worthy of attention.

The chief interest is centred in the Hohentwiel, both on account of its imposing size and the greater facilities for studying its history, afforded by its accessibility. It is approached by a tolerably well-kept roadway, formed on the surface of the *débris* and volcanic ash which surrounds the cone, and ascending like a spiral stair as far as the inn and farm-house, situated on a level ledge to the right. From this the road again ascends, first in a straight and then in a winding direction, over the ashes, until by a most circuitous path the first gate is reached, and the visitor passes within the outer wall of the ancient fortress.

At the inn the visitor, by a walk of a few yards, can reach the base of the overhanging rocks, which tower above him to a great height, and whose bluish-grey walls are adorned by the rich yellow of a lichen, which is said to be found on phonolithic rocks alone.

At the base of these perpendicular cliffs there is an enormous quantity of flat oblong-shaped fragments. They form a steep slope round fully more than one-half of the circumference of the cone, and as they lie loosely together they render the base of the cliffs almost inaccessible, or at least only to be reached with immense difficulty. Farther down the slope they have become somewhat compact, and, as the freshly-fallen fragments rarely slide down to any great distance, a considerable number of trees and bushes have taken root amongst them, and grow luxuriantly. It has been conjectured that this immense amount of *débris* is not entirely due to weathering, but that a considerable proportion has been removed from the summit when it was being converted into a fortress in mediæval times.

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One of the most striking features of the Hohentwiel is the perpendicular nature of the rocky walls, which tell in the simplest manner their own tale, and enable the geologist to read the riddle of their origin.

The explanation is to be found on the N.W. and W. sides, where may be observed, shortly after leaving the inn, the commencement of an immense sloping heap of volcanic ash, upon and sometimes through which the road leading to the summit has been made. This heap, which by means of its naturally-formed inclined plane, affords the only means of access to the summit, otherwise quite inaccessible to man, has, we naturally infer, issued from the same vent as that by which the compact phonolith has appeared. If we imagine this ash to have been first upheaved, and to have formed an immense cone through which the phonolith was forced up, we have at once a mould, with perpendicular sides, in which the liquid mass would be supported until it cooled. The mass thus ejected through the ash would seem not to have had sufficient force, or not to have been in sufficient quantity, to pierce the summit of its ashy covering, otherwise we should have had an overflow, covering the ashes on one or more of its sides, and protecting them from the agencies which afterwards removed them from all sides but one. This central cone of phonolith at and after its formation would be hidden by its covering ash beds.

And there it slept quiescent from Tertiary times until a wondrous change came o'er the spirit of the scene—till fogs, and rains, and ever-increasing sleet, and snow, and chilling winds, announced to plant and every living thing that the advent of the Glacial period was at hand, and that the mighty Rhine glacier was creeping slowly but irresistibly from its birth-place in the Alps. And then the glacier, spreading north and west, laid siege to this ash-encircled and ash-covered rock on its eastern side, and, driving slowly before it the feebly-resisting mass of ash, disclosed for the first time the kernel of rock within, at the same time chilling the mighty ribs which had once glowed in living fire. But the kernel of phonolith was only bared to be buried under the vast river of ice which was now crushing over its summit on its northward and westward course. That this actually occurred is proved in the most conclusive manner by the fact that moraine rubbish has been found on the summit of the peak. The course of the glacier afterwards

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may be traced out clearly by the blocks of phonolith which it has left behind it at Riedlingen and Ehingen, 25 miles N.W. from the peak, the peculiarity of the rock rendering it impossible to mistake it even when found far distant from its place of origin. Other equally unmistakable signs of the prevalence here of the Glacial period are to be found in the contents of the caves in the Höhgau district, the bones of the Siberian mammoth, the woolly rhinoceros, the cave bear, the reindeer, the polar fox, the alpine hare, and the white grouse (schneehuhn), having been found in them, and carefully preserved in the admirable museum in Stuttgart (founded by the King of Wurtemberg, and supported by the State), in which the geological treasures of all the formations that occur in the kingdom are carefully preserved, admirably arranged, and laid open to the public inspection daily. This museum is under the charge of the State geologist, Dr. Oscar Fraas, an eminent scientific man and highly accomplished gentleman, from whom strangers receive the greatest attention and courtesy.

A digression may be excused here to allude to the remains of the Mammoth, found in different parts of Wurtemberg, in particular to a group of 13 tusks and 3 molars found at Seelberg, which were excavated in an unbroken mass, and re-deposited, as they lay, in the museum. A melancholy interest attaches to this group, especially if the student be of Swabian birth, for its excavation cost the people the life of their king, whose enthusiasm in the study of nature led him to stay daily for many hours beside Lieut. Natter, the acting engineer, until he caught, in the rigorous weather of the end of October, 1816, a cold, from the consequences of which he died. The largest of the Mammoth tusks in this collection is 12 ft. 10 in. in length. After the disappearance of the glacier, which had exterminated the former denizens of the pools, swamps, and forests of the Höhgau, the giant salamanders and turtles, the emysaura, or chelydra, the poplar, maple, cinnamon, and camphor-tree, another actor steps upon the scene. In this district we find some of the earliest traces of man; but, from the absence of the remains of domestic animals and utensils among those tools formed by the aid of flints from reindeer bones, it is probable that the first human visitors to this district came as hunters in the summer season only, without permanent dwellings, returning by the valley of the Danube to the eastern land, from which they had come as pioneers.

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The first traces of man found on the summit of the Hohentwiel indicate that he had ceased to be simply a nomadic hunter, and that he had commenced to practice agriculture and live in fixed dwellings. We find here fragments of earthenware of the rudest description, as well as those which show the first attempts at ornamentation, in the shape of vessels, pots, and plates, mingled with fragments of split bones of the ox, stag, pig, and sheep. These were found in a black layer of ashes, when excavations were being made under the foundations of the oldest part of the fortress, but which had been mostly removed when the fortress was begun to be built, and thrown over the precipitous cliffs, at the foot of which, by diligent search, some fragments may still be found. A fine collection of these remains may be seen in the Rosengarten museum in Constance.

The nature of the rock itself merits our consideration, as it is comparatively rare. A fresh fracture shows a dark grey or blue colour, which changes under the influence of the weather to a light grey, with a faint shade of yellow or brown; and there can be easily observed the sparkling, colourless crystals of sanidine-felspar, the black and less lustrous crystals of hornblende, and occasional crystals of titanite. Under the microscope the crystals of hauyne or nosean become visible, the colours of which vary considerably according to circumstances. In this rock they generally appear of a bluish or greyish-green colour, which sometimes appears only on the edge of the crystal, sometimes in spots in it, and sometimes penetrated with a delicate fibrous network of bluish-green material, which is acted upon by polarised light. Nepheline is mixed with the hauyne and nosean, but the latter prevails to such an extent that Vom Rath has termed it nosean-phonolith, and Sandberger hauyne-phonolith. Hitherto the distinction made between hauyne and nosean is this, that while both are silicates of alumina and soda, hauyne contains sulphate of lime, and nosean sulphate of sodium, in addition. Both minerals contain very small proportions of iron and potassium.

Zirkel says that nosean is to be detected in all phonolites in microscopic crystals. Hauyne is usually of a deeper blue than nosean, but this blue colour may be imparted to the latter by heating it. Von Lasaulx has observed that, in the once fused volcanic bombs and lapilli of the Lacher See, in the Eifel, hauyne alone is found, which has led him to infer that the two are

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identical, their variations being due to different degrees of heating. This opinion was confirmed by the latest researches of Rosenbusch,* who includes both under the older name of hauyne. Colourless hauyne may be artificially coloured by heat.

In all exposed portions of the phonolite, the process of weathering has changed the hauyne to a dirty yellow substance, which for the most part consists of divergently-running fibrous veins. With the naked eye the colourless crystals of the sanidine are visible, but the crystals are dimmed by spots and cracks, and the brown opaque spots in the mass may arise from decomposed titanite. The microscope shows clearly the distinct stages between the fresh hauyne and that in the decomposed condition in which it passes into natrolite. Zirkel has observed a crystal, the half of which was quite fresh, the other half having changed into the yellow fibrous substance characteristic of natrolite. This shows itself most thoroughly in polarised light, when the changed part appears to be coloured and the unchanged a deep dark black.

Natrolite, which is almost identical with analcime, is found in veins on the northern side of the cone, and only there. It is never found otherwise than in this form, as it does not form a constituent of any rock. Crystallisation commences on each side of the fissures in the rock, and kidney-shaped concretions are formed with a fibrous structure radiating from their centres. If the phonolith be examined at the sides of a vein of natrolite, it will be observed that the hauyne has entirely disappeared; that the natrolite owes its origin to the hauyne may be demonstrated from its chemical composition. This mineral was first brought into notice in 1803, by Selb, who called it högauite, but in the same year it was named natrolite, by Klaproth. It has been alluded to in 1792, by Razoumousky and Dolomieu. The Elector, afterwards King, Friedrich, excavated it on the north side of the Hohentwiel, and caused it to be polished by the prisoners in Stuttgart for the ornamentation of the stairs of his palace there.

* "Mikroskopische Physiographie der massigen Gesteine," 1877.

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[ABSTRACT.]

XXXVI.—*On* GRAPTOLITES. By CHARLES LAPWORTH, F.G.S., Corresponding Member.

[Read 2nd April, 1880.]

IN the first edition of his famous work, the "Systema Naturæ," published in 1736, the great Swedish naturalist, Linnæus, proposed the name *Graptolithus* for certain natural markings occasionally found upon stones, which are not true fossils, but are mere superficial stainings, having the deceptive appearance of being organic remains. In the twelfth edition of the "Systema," however, Linnæus unwittingly figured and described two true fossils under the head of *Graptolithus*. One of these, his *Graptolithus scalaris*, was founded upon some strange markings found upon pieces of broken stone collected in Scania, in the south of Sweden. In 1821, Dr. Wahlenberg collected some specimens of the *Graptolithus scalaris* from Linnæus' original localities. These he submitted to a careful examination, and reached the conclusion that they were the remains of fossil Orthoceratites. Through the subsequent researches, however, of Nilsson, Portlock, and Barrande, who discovered and studied many genera and species of fossils of the same type as the original *Graptolithus scalaris*, it has been demonstrated that these so-called *Graptolithus* or *Graptolites* are the petrified remains of Hydroida, allied to the modern Zoophytes of our sea-coasts.

These fossil Graptolites are all plant-like forms, and are of many different shapes—linear, leaf-like, tree-like; simple and compound. They all show peculiar notches or teeth upon their outer margins, and are now transformed into shining carbonaceous matter. They are separated by palæontologists into two main groups—the *Rhabdophora* and the *Cladophora*. The *Rhabdophora* stand almost alone in the animal world in the possession of a peculiar rod or solid axis imbedded in their substance.

The lecturer showed the general identity of the structure of these *Rhabdophora* and the modern Plumularian Zoophytes, and gave a description of all their main divisional families, illustrating his remarks by a series of diagrams. Their mode of development, from the embryo to the adult organism, was next described and

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compared with that of the modern sea-firs. Their mode of reproduction was next noticed in detail. In this department the results of the recent dredgings made around our own coasts, and in the neighbourhood of the Gulf Stream, have been of the greatest service in enabling us to gain a proper conception of the methods of reproduction among the Graptolites. The deep-sea Hydroida discovered in these dredgings have their reproductive sacs occasionally protected by certain basket-like, leaf-like, or finger-like structures. These, the lecturer showed, were of the same general type as those in the ancient Graptolites already known to possess reproductive appendages.

In conclusion, the author gave a short summary of the results worked out by himself, with respect to the range of the Graptolites in time and space. They are exclusively confined to the Lower Palæozoic rocks—appearing in the middle Cambrian, and disappearing at the summit of the Upper Silurian. Contrary to the opinions of the earlier palæontologists, it now appears that they are greatly restricted in their vertical range, while they have at the same time a very wide horizontal distribution. This renders them of the greatest service to the geologist, who is enabled by their aid to easily unravel the complexities of succession among the highly-convoluted Lower Palæozoic rocks.

XXXVII.—Notes *on a* Fossiliferous Post-pliocene Bed *at* Gourock. By Thomas Steel.

[Read 22nd April, 1880.]

About three years ago, while the houses now built between the Gourock Toll and Fort Matilda were in course of erection, a cutting for a drain was made through the field which lies between the Gourock Road and the river. During the cutting the workmen passed through a post-pliocene bed containing shells. These were of the species common in the Arctic beds of the Clyde valley; the most notable, however, being *Astarte borealis*, Chemnitz, fine specimens of which were common.

A few months ago excavations were made behind the Gourock toll-house, just at the point where the high and low roads meet, to obtain sand for building purposes, and, as in the former instance, the shell-bed was well exposed, I was able to collect a considerable number of specimens.

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Proceeding downwards, the following are the details of the section:—

	Feet.	Inches.
Surface Soil,	0	6
Coarse Gravelly Sand,	2	9
Sand, with Shells and a few Stones,	9	0
Laminated Clay,	1	8
Boulder Clay,	Not cut through.	

The organic remains, a list of which is appended, were chiefly found in the lower 3 feet of the sand, the upper 6 feet being comparatively barren. A water-worn flint was found in the gravel overlying the shelly sand. No organisms were detected in the lower laminated clay, though it was carefully searched.

It is curious to note that algæ and mosses similar to those recently described to the Society by Mr. David Robertson, F.L.S., F.G.S., as occurring in the Garvel Park clay, were common and well preserved.

Those specimens of *Cyprina Islandica* in which the valves were found in close approximation had a white fibrous substance between the hinge teeth, which was evidently the remains of the ligament. It may also be observed that the shells of the Cyprinæ were very thick and heavy. A single valve of *Saxicava Norvegica* was found by Mr. Thomas Scott, of Greenock.

The list of fossils does not include the Foraminifera and Ostracoda, of which numerous species were found. I am much indebted to Mr. David Robertson for his uniform kindness in naming specimens.

ALGÆ:—	
Sphacelaria cirrhosa.	Common.
Dictyosyphon fœniculaceus.	,,
Desmarestia aculeata.	,,
Melobesia polymorpha. Linnæus.	
MUSCI:—	
Hypnum. Various species.	,,
PORIFERA (*Spongidæ*):—	
Cliona celata. Grant.	,,
ECHINODERMATA (*Ophiuroidea*):—	
Plates and spines.	
ECHINODERMATA (*Echinoidea*):—	
Echinus Dröbachiensis. Müller.	,,
,, *sphæra.* Müller.	,,
ECHINODERMATA (*Spatangidæ*):—	
Plates and spines.	,,

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ANNELIDA (*Tubicola*) :—	
Serpula vermicularis. Ellis.	Common.
Spirorbis spirillum. Lin.	,,
CRUSTACEA (*Cirripedia*) :—	
Balanus crenatus. Brug.	Rare.
,, *porcatus.* Da Costa.	Common.
Verruca Strömia. Müller.	,,
MOLLUSCA (*Conchifera*) :—	
Anomia ephippium. Lin.	,,
Pecten Islandicus. Müll.	,,
Mytilus edulis. Linn.	Rare.
,, *modiolus.* Linn.	Common.
Nucula tenuis. Mont.	Rare.
Leda pernula. Müller.	,,
,, ,, var. *macilenta.* Steenstrup.	Common.
Montacuta bidentata. Mont.	,,
Axinus flexuosus. Mont.	,,
Cardium fasciatum. Mont.	,,
Cyprina Islandica. Linn.	,,
Astarte sulcata. Da Costa.	,,
,, ,, var. *elliptica.* Brown.	,,
Tellina calcaria. Chemnitz.	,,
Scrobicularia alba. Wood.	,,
Mya truncata. Linn. Fry.	,,
Saxicava Norvegica. Spengler.	Rare.
Fry of *Saxicava rugosa.* Linn.	,,
MOLLUSCA (*Gasteropoda*) :—	
Chiton, sp. ?	Common.
Tectura virginea. Müller.	,,
Puncturella Noachina. Linn.	Rare.
Trochus helicinus. Fabricius.	,,
,, *Grœnlandicus.* Chemnitz.	,,
Lacuna divaricata. Fabricius.	,,
Littorina littorea. Linn.	Common.
,, *rudis.* Maton.	,,
Rissoa striata. Adams.	,,
,, *parva*, var. *interrupta.* Adams.	,,
Natica Grœnlandica. Beck.	Rare.
Buccinum undatum. Linn.	Common.
Trophon truncatus. Strömer.	Rare.
,, *clathratus.* Linn.	,,
PISCES :—	
Vertebræ and bones.	Common.
INSECTA (*Coleoptera*) :—	
Elytra, legs, &c.	,,

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XXXVIII.—*On the* Relations *of the* Glacial Deposits *of the* Clyde *and* Forth *to those of the* North-west *of* England *and* North *of* Ireland. By T. Mellard Reade, C.E., F.G.S., F.R.I.B.A.

[Read 22nd April, 1880.]

Years of careful study of the drift beds of the North-west of England convinced me that to arrive at a correct interpretation of the glacial phenomena, as they are here exhibited, demanded also a study of the beds on the opposite coast of the Irish Sea, in Ireland, together with those of Scotland.

Looked at in this light, as deposits skirting the basin of the Irish Sea, it appeared to me that it would be possible to see in what way local influences, the nature of the rocks, elevation and configuration of the land, and other circumstances, affected the several deposits. In this way inferences might be drawn of much more general value than could possibly accrue from a more limited survey, however minute. As regards the North-west of England, that minute knowledge I had already acquired, so I devoted my holiday tours in 1878-9 to a survey of those localities in Ireland and Scotland I thought likely to yield the best results.

Deposits of the North-west of England.—Stated briefly, these deposits consist mostly of beds of clay, sand, and gravel, containing almost universally fragments of marine shells* (44 species), the *facies* of the group betokening a more northern condition of things than now exists, *Astarte borealis* being, in my opinion, the typical shell. Still the group does not present so great a remove from what prevails in our seas at present as to form a very sound basis on which to build up a glacial superstructure. On the other hand, there are interspersed throughout the clays, and in some cases the sands, boulders of travelled rocks, which have been traced to their origin in Cumberland, Westmoreland, and the South of Scotland.† Most of these are more or less planed and scratched, some intensely so. There are also found large erratics, weighing from half a ton to three or four tons, of granite, syenite, diorite, dolerite, felstone,

* A list of these is to be found in my paper, *Quart. Journ. Geol. Soc.*, "On the Drift Beds of the North-west of England," February, 1874.

† See Mackintosh's numerous papers in the *Quart. Journ. Geol. Soc.*

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volcanic ash, Carboniferous limestone, &c., and these are, excepting where decomposition has obliterated the markings, nearly always well planed and grooved along the longer axis. From the time of Joshua Trimmer until now attempts have been made to distinguish the various beds of clay, sand, and gravel from each other. Trimmer* divided them into "Lower Erratics," "Boulder-clay," and "Upper Erratics" (sand and gravel); Professor Hull, more lately, into "Lower Boulder-clay," "Middle Sands and Gravels," and "Upper Boulder-clay;" and this latter classification is the one now most generally adopted. My own investigations lead me to doubt the value of any of these classifications, and, what makes it more confusing, there is no real agreement among the supporters of this classification as to which division special beds belong. Thus Mr. De Rance† considers all the shells of my list to be derived from the "Lower Boulder-clay," while Mr. Mackintosh and Mr. Shone‡ commit them to the "Upper Boulder-clay." As regards the fauna of the sand beds, I have shown§ that really no geological distinction can be based on these grounds, while, on the other hand, I have failed to trace out any stratigraphical connection that would support any of these theories of geological subdivision.

In the low-lying plains of Lancashire and Cheshire, when the Boulder-clay is stripped from the surface of the rock, the latter, if it be sufficiently hard, is, so far as my experience goes, invariably planed and striated, generally in a north-westerly direction. When the rock is not hard there is usually a bed of sand between the clay and the rock, of the nature of the rock itself; red sand on red rock, yellow sand on yellow rock, and the unstratified bottom bed of this never contains travelled stones, though, in places where the sand appears to have been rearranged and rudely stratified, travelled stones are to be found.

It will be unnecessary for me to go further into the details of this division of my subject, especially as I am preparing a full report of my investigations for the London Geological Society;

* "On the Erratic Tertiaries bordering the Pennine Chain," &c.—*Quart. Journ. Geol. Soc.*, 1851, p. 201.

† "The Superficial Geology of South-west Lancashire," by C. E. De Rance, "Memoirs of Geol. Survey."

‡ "On the Glacial Deposits of West Cheshire."—*Quart. Jour. Geol. Soc.*, May, 1878.

§ *Geol. Magazine*, dec. ii., vol. iv., pp. 38-39.

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suffice it to say that there is every evidence of the deposits having formed an extended sea-bottom, and that they contain representatives of all stages of depression up to over 1400 feet. The striated stones included in the beds are almost universally travelled ones, while the materials of the matrix forming the bulk of the deposits are undoubtedly mostly local, the clay being derived from the Triassic marls, and the sands from the degradation of the Triassic and Carboniferous sandstones. These are the great deposits of the plains; to those of the mountain districts I shall only require to refer incidentally in connection with the Scotch and Irish beds.

The Irish Drift.—In Belfast Lough, on the north shore, is to be seen a Boulder-clay that corresponds very closely with what we find in Lancashire—the matrix being evidently largely derived from the Triassic marls which are in proximity. It contains, among other stones, large blocks of dolerite and indurated chalk, the latter showing evidences of glaciation. I put it down at first sight as a marine deposit, from its characteristic features having so close a correspondence to our own Boulder-clay; and I have been since informed by Mr. Joseph Wright, of Belfast, that *Leda pernula* and *Leda minuta* occur in the clay with the valves attached, together with many foraminifera, including *Polystomella arctica*, which is found in abundance. At Ballygally Head, between Larne and Cushendall, is a section showing sand and gravel lying under unstratified Boulder-clay. They are classed by some geologists as "Middle Sands and Gravels," but I have attempted to show * that they do not in any way represent "interglacial" conditions, which the advocates of the tripartite division contend the "Middle Sands and Gravels" do—that they, in fact, lend no support to such a geological subdivision.

On the west coast, in Galway and Clew Bays, a Boulder-clay is to be found which is evidently the equivalent of the Scotch Till, though the matrix is derived mostly from limestone rocks. This Till contains no marine forms, or, indeed, any organic remains whatever. In each case it is crammed full of rocks, derived from within the same drainage basin; but at Blake Hill, in Galway Bay, from the calcareous nature of the clay, it has set so hard that the sea-face stands vertically in cliffs, like walls of concrete. In Clew

* "On a Section of Boulder-clay and Gravels near Ballygally Head," &c., *Quart. Journ. Geol. Soc.*, Nov., 1879.

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Bay the materials forming the numerous islands of drift are rather looser, and the islands finish with a steep face to the sea, very regularly furrowed by rain-wash and sea-spray. That such excessively fine material as composes the matrix could be deposited except in water it is difficult to realise; but why Professor Hull,* in his "Physical Geology of Ireland," without a word of explanation, should classify this Till with his Lower Boulder-clay of Lancashire, which is admittedly a marine deposit, I know not, excepting it be from a natural tendency to see a three-fold division in all groups of strata.

On comparing these Irish deposits with those of the North-west of England, it will be seen that the unfossiliferous Boulder-clay or Till predominates in Ireland, though there exist on a smaller scale the representatives of the marine clays and sands of Lancashire. It also appears, from the investigations of the Rev. Maxwell Close—who has done so much for the glacial geology of Ireland—that the Boulder-clay usually rests upon glaciated rock surfaces, though I am not aware if the same holds good in regard to the rocks on which the marine deposits rest.

Glacial Beds of the Clyde and Forth.—In examining the glacial beds of the Clyde and Forth, the thought uppermost in my mind was, what relation does the "Till" of Scotland bear to the Boulder-clay of the Lancashire plains? A visit to various sections in the Clyde basin, under the kind guidance of Mr. Robert Craig, of Beith, and of Mr. Bell, your late secretary, and from the directions of Mr. David Robertson, F.G.S., seemed to establish these several points of similarity and difference :—

(1st.) Instead of lying in a continuous approximately horizontal sheet, filling up the irregularities of the rocky land-surface, as do the Lancashire deposits, the Till of the Clyde basin is broken up into hills and hummocks, which apparently bear little relation to the form of the land-surface beneath—as, for instance, the hill on which that fine-looking building, the University of Glasgow, stands.

(2nd.) The Lancashire Boulder-clay is undoubtedly rudely stratified—that is to say, not that it merely contains current-bedded deposits of sand or gravel, but the general arrangement of the several groups of materials or beds is horizontal. I have traced beds of sand rudely continuous over a railway section three miles long—dying out and broken, it is true, but still to a certain extent

* "Physical Geology of Ireland," page 83.

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dove-tailing into each other, and having a general but broken horizontal stratified arrangement. In another case I traced a bed of sand, not more than six inches thick, containing broken shells, a distance of three-quarters of a mile, following pretty closely the form of the ground above.

Nothing that I saw in the Clyde or Forth valleys showed a stratified arrangement of the Till. Unfortunately, it takes many years of acquaintance with "sections," and persistent visits to excavations as they progress, to get a full acquaintance with the phenomena of the drift. This I have been able to do in my own district, but in Scotland I must necessarily trust to "typical" sections, explanations from local geologists, who in Scotland are many and good, and reference to those classic works on the subject of glacial geology by Smith of Jordanhill, Jamieson, Geikie, Robertson, and others. Although there exist in places divisions, and included beds, both fresh-water and marine, in the Till, and in some cases it may show signs of rude stratification, it is universally described by all observers as a "stony, unstratified Boulder-clay."

(3rd.) In Lancashire, on the plains the included stones are almost invariably travelled ones. There are very few examples to be found from the Trias—the rocks on which the deposits lie—but occasionally fibrous gypsum from the red marl, and pieces of sandstones from the Bunter or Keuper, are met with. In more abundance Carboniferous sandstones occur, but the great bulk of the boulders and erratics are undoubtedly from the Lake District, the South of Scotland, and some perhaps from Wales. Antrim flints are also not unfrequently met with. The stones appear to me to be more universally striated than those of the Till, especially the large erratics; but I would not like to pronounce too positive an opinion on this head.

The proportion of stones to the whole bulk of the clay in examples I tested at Great Crosby varied from 1 in 130 to 1 in 1,200—the average being estimated at 1 in 900. The Till, on the other hand, is often half stones to half clay. To show how different is the nature of the Lancashire Boulder-clay, I may mention that it is from it that all the local bricks are made. The clay is simply tempered, and the stones picked out; or, with machine-made bricks, often the raw clay is thrown directly into the mill after the large stones are picked out, the smaller ones being crushed

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between the rollers. This treatment would be impracticable with ordinary Till, but Dr. James Geikie* states that some is dug from which bricks can be, and in fact are made.

The stones in the Till of the Clyde mostly belong to the area of the Clyde basin, although they appear to have travelled eastward up the Clyde. Mr. Bell and Mr. Robertson kindly supplied me with a set of excellent examples, taken from the Stobcross Railway cutting, which bear this statement out. It is not difficult to see, if the stones were glacier-borne, that from the trend of the Highland valleys opening into the Clyde, and the position of the elevated land in Argyllshire, which generated the glaciers, that this would constitute the line of least resistance, though at first it sounds anomalous to say so. I saw some excellent examples of Till in the excavation for the New Docks at Leith, and all that I have said of the Till of the Clyde is equally applicable to that of the Forth, excepting that the latter appeared more largely composed of grindings of the Carboniferous shales.

(4th.) The Lancashire Boulder-clays show their unmistakably marine origin by the fragments of marine shells and the foraminifera they yield in a lesser measure on washing. The Till is, as Till, devoid of marine or other organisms, but occasionally contains included beds of sand, in which marine shells are found, as at Airdrie,† or it rests upon such beds, as at Kilmaurs, in Ayrshire.‡ But those conditions seem sporadic and exceptional.

There is a so-called Shelly Till to be found in various parts of Scotland, the nearest being that described by Mr. Jack.§ Mr. Jamieson has described a Shelly Till in Caithness,‖ and Dr. James Geikie also gives several examples. Unfortunately, I have not seen any sections of this so-called Till, but the manner in which the shells occur in it, as described, reminds one strongly of the Boulder-clay of Lancashire. It is extremely probable that these Shelly Tills are similar deposits to the Lancashire Boulder-clays, modified by local conditions, among which the most important is proximity to mountains.

* "Great Ice Age," 1st ed., p. 11.

† "On the Phenomena of the Glacial Drift," Geikie, p. 58.

‡ *Trans. Geol. Soc., Glasgow.*

§ "Notes on Till with Broken Shells."—*Ibid.*, vol. v., part 1, p. 5.

‖ *Quart. Journ. Geol. Soc.*, 1866, p. 265. A very graphic account of this Shelly Till will be found in Smiles' "Life of Robert Dick," 1878.

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The nearest approach to the Scotch Till I have seen in Lancashire was disclosed by the excavation of a trench for the puddle wall of the Yarrow Reservoir at Rivington, 600 feet above the sea-level. This intersected in two places very deep gullies in the rock, filled up with drift. Excavations at the side of the reservoir showed the same drift or Till, containing very large blocks of Carboniferous sandstones, none that I observed being glaciated, and mingled among them were boulders of granite and other northern rocks. The proportion of stones was very nearly that of the Scotch Till, and in general appearance the sections presented the blue-black colour of those of the Leith Docks. The bulk of the stones was of local origin, derived most probably from the immediate valley. If the Till of the Clyde had mingled with it stones from other valley systems outside its own basin, it would very nearly resemble the Yarrow drift.

(5th.) In a section of the new Cartsdyke Dock at Greenock the base of the Till was exposed. It rested upon a reddish sand, evidently derived from the Old Red Sandstone* below. At another point there was a striated floor of rock exposed, having a direction N.W. by S.E. This presented such an exact counterpart of what I have constantly seen between our Boulder-clay and the Triassic rocks, that I was much struck with the parallel.

(6th.) The laminated brick-clays of the Clyde, which rest on uneven surfaces of Till, have no parallel that I know of in the North-west of England, certainly not in Lancashire. The remarkable fact is that, although the character and constitution of the clay show that it must have been formed under waning glacial conditions—even if such conditions existed at all—the fauna apparently exhibits quite as northern a *facies* as is presented by the shell fragments of the Lancashire Boulder-clay. A reference to the respective lists will show this, without the necessity of my repeating them here. This is certainly striking, as I am convinced that the Lancashire Boulder-clay is not *remanié*, as held by Professor Hughes, but is a clay representing true glacial conditions.

So far I have not touched the question as to whether there are *two* Tills, as held by some Scotch geologists, my wish being to bring out first in bold relief only the broad divisions of the subject. I may briefly state that a very careful consideration of all that has

* This Sandstone the Survey now place, I understand, in the Calciferous series.

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been hitherto advanced by Dr. James Geikie in proof thereof fails to show me that the phenomena relied upon cannot be explained in a simpler way, so as to satisfy all the known conditions. At the same time, I am free to admit that the evidences of what are called interglacial conditions are more distinct in Scotland than they are in the marine beds of the North-west of England, as I go so far as to declare that in the latter case the evidence is of the flimsiest and most unsatisfactory nature. But I would point to that admirable paper by Professor Archibald Geikie, "On the Phenomena of the Glacial Drift of Scotland," published in 1865 by this Society, to show that at that period such an explanation of the occasional occurrence of fresh-water and marine beds in the Till did not present itself to him. Interglacial conditions would, no doubt, account for these things and for included mammalian remains, but they would also account for much more which we do not find. Dr. James Geikie himself says:—"Indeed, when we compare the bulk of these beds to that of the Till, we must allow that they form but a small fraction of the drift deposits."* It is, as I hope to show, invoking an unnecessary amount of machinery to account for exceptional effects; at the same time, I am quite prepared to believe in these recurrent periods, if further and stronger evidences be forthcoming. In the meantime, it does not really affect the main question of the relation of the Lancashire deposits to those of Scotland, which it is the object of this paper to discuss.

It is almost universally considered that the Scotch Till is a land deposit, formed under great glaciers, or an ice-sheet. Before investigating the subject on the ground, I accepted this idea, and correlated the red sand and rubble at the base of the Lancashire Boulder-clay with the Scotch Till, as I then considered, and see no reason to alter the opinion now, that the red sand and broken rock were formed by the grinding of the rock by land ice.†

The same phenomena occur under the Till, where the conditions are similar, as shown in the Greenock Dock section; therefore I now put down these sands in the two countries as equivalent deposits, underlying in one case the Boulder-clay, in the other the Till.

It now remains to consider what relation the undoubtedly marine clays of the Lancashire plains bear to the Scotch Till, and to do this

* "Great Ice Age," p. 167.

† *Quart. Journ. Geol. Soc.*, vol. xxx., p. 27.

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it will be necessary to traverse the reasons that have decided so many good observers to declare that the Till is a purely land deposit or ground-moraine, formed under either the ice-sheet or local glaciers.

Although not agreeing with those extreme glacialists who imagine an ice-cap to have existed over the larger portion of the northern hemisphere, nor even with those who, more modestly, bring glaciers from the mountains of Scandinavia to plough up the bed of the North Sea, score British rocks, scoop out the Severn valley, and land Shelly Till upon eminences 1,400 feet high, there is to my mind undoubted evidence of the former existence of a large extension of ice, in the form of confluent glaciers, radiating from the mountain systems of the British Isles. The scoring of the Triassic rocks of Lancashire, the rounded surfaces of the dolerite of Fairhead, in the north-east of Ireland, and the innumerable evidences of striation, so diligently investigated by the Rev. Maxwell Close over a large area in Ireland, the researches of Jamieson and Geikie and other good observers in Scotland, of Tiddeman, Clifton Ward, and many local geologists in England, all afford cumulative evidence of this, although there are those still who attribute the scoring of the rocks on the plains to the movements of icebergs—the first idea that presented itself to geologists—and point to the wide limit of variation in the direction of the striæ in proof that they could not be the effect of land ice. Keeping my mind still open to conviction, to receive new ideas, or, if need be, revert to old ones, the absence, so far as my own observations go, of any accompanying phenomena which indicate icebergs as being the planing and scoring forces, induces me to believe that these groovings are due to land ice; although undoubtedly the difference in the direction of the striæ in Lancashire, amounting to 30 degrees, presents a difficulty which can only be surmounted by assuming that, as the movement of the ice must follow the line of least resistance, this differential direction occurred from the accumulation of snow varying at times in different areas.

If, therefore, we assume the former existence of glaciers on an extended scale, what would be the effect of such action in a long course of ages? Here I am compelled to give in my adhesion to Professor Ramsay's theory that one result would be the formation of rock-basins by unequal action of degradation on the underlying rocks, dependent upon the varying thickness and consequent weight

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of the glacier at different points of its course, the form and area of its snow "gathering grounds," the configuration of the valley, and the varying hardness of the rocks it traversed. In a paper by Amund Elland,* it is calculated that the glaciers descending from the Justedalsbræen, in Norway, covering an area of about 870 square kilometres, bring down annually 180,000,000 kilograms of mud. This amounts to about 529 tons of mud annually per English square mile, derived, it must not be forgotten, from the hardest rocks. If the denudation were distributed equally, this would lower the country at the rate of one foot per 3,904 years, but, as the differential denudation must necessarily be much more than that, it may at a favourable point reduce one part as compared to another one foot in 3,000 years. It will readily be seen that, under favourable conditions, a lake basin 50 feet deep could thus be scooped out in 150,000 years, not too long a time to allow for a glacial period.† The general effect of this grinding action, assisted by the water which must necessarily result from the heat developed by mechanical action, reinforced by that percolating from the surface of the glacier, would be to clear everything before it. It is possible to conceive that local conditions might exist at places favourable to the accumulation of matter under the glaciers, in the form of what is called a ground-moraine, but to assume, as is done by those who support the land origin of the Till, that the very same agent, without any ostensible cause being alleged for the change, first ground the rocks to a smooth surface generally, and then very uniformly covered them up in the same track with a coating of Till, in many cases over 100 feet thick, is, to my mind, a most unphilosophical begging of the question. No doubt the general absence of marine remains in the Till has led to this opinion, as it is thought there is no escape from the conclusion that if it be not a *marine* it must be a *land* deposit. For one, I am unwilling to accept this as a necessary alternative, as it is quite possible, nay probable, as I hope I shall show, that to a large extent it may really be intermediate between the two.

As I have already stated, the very fine, calcareous, muddy matrix

* *Quart. Journ. Geol. Soc.*, 1877, vol. xxxiii., p. 158.

† No doubt part of the mud is derived from the grinding of the stones embedded in the glacier. Keeping this in view, the estimate of the rate of erosion is a moderate one.

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of the Boulder-clay of the West of Ireland led me to doubt if such could have remained under land ice. It seems to me also impossible to escape from the conclusion that if the glaciers scooped out rock-basins, they could not afterwards fill them up without very great changes having in the meantime taken place. Then, what were the nature of these changes? One of the best-established facts in glacial geology is that a very great depression or series of depressions of the land took place, amounting in England to not less than 1,400 feet,* and in Scotland not less than 500 feet,† but probably, as held by Dr. James Geikie, very much more, the evidence of Kames pointing to 1,238 feet.‡

This gradual subsidence, extending over a great length of time, judging from what we know of the rate of such movements now, must have had a very great effect on the nature of the deposits. The ice-sheet would shrink towards the mountains, the plains of Lancashire become a sea-bottom. Glaciers entering the sea, and, calving off as icebergs, would deposit their freight as they melted, strewing the striated boulders on the sea-floors, and leaving them as we find them in the marine Boulder-clays. All the land above sea-level would contribute, by means of sub-ærial denudation, assisted by melting snow, materials which the rivers would take to the sea to form the great bulk of the matrix of the Boulder-clay. Tidal currents would arrange clay and sand, as we find them arranged, in rude horizontal stratification. Nearer to the mountains generating the glaciers a very considerable length of each glacier must, before it reached a depth sufficient for the floating power of the water to calve off icebergs, have protruded many miles into the sea. In proportion to the depth of water it "drew," to use a nautical phrase, would the weight of the glacier on the bottom be diminished. Here, therefore, we have the conditions under which the materials, great or small, ground and torn from the land and carried under the glacier, would finally be deposited under it.

With a "hydraulic head" outside the glacier, the streams of water flowing under the glacier would be so lessened in velocity as to allow of the deposition of even the finest sediment. Nor would there be any chance of organic remains occurring in the deposit. It is also quite conceivable that the movement of the glaciers would

* Moel, Tryfaen.—Shells. † Airdrie.—Shells in Till.
‡ "Great Ice Age," p. 255.

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be so clogged by these accumulations that the deposit might tail off and run up under the glacier landwards, even above sea-level. As the land subsided these conditions would travel inland to the extent of the submergence, and, given the requisite time, accumulate all those masses of unstratified Till we find in the lower valleys of Scotland.

The Till formed under the glaciers would be succeeded by marine conditions, and thus the Shelly Till be formed. A local growth or retrogression of a glacier might in this way form two Tills, with a marine bed in the midst. Such occurrences may be thus explained, without going so far as to invoke interglacial conditions. But, while giving this as a general explanation of the Till, I am not at all satisfied that an unstratified deposit, without organic remains, may not have been formed in the sea outside a glacier. The section of the Yarrow Reservoir, Lancashire, proves to me that a deposit simulating the Till, and containing no marine organic remains, might be formed in the sea at a point where a large local supply of rocks might contribute to its formation. It must not hastily be assumed that the absence of shells proves a deposit not to be marine. It would be almost as philosophical to assume that because marine shells are occasionally found in the Till it is *all* a marine deposit. It is a striking fact that though the whole of the Pennine chain has been under water, only at one place, near Macclesfield, 1,200 feet above the sea, have marine shells been found, and those mostly fragmentary. The same with Wales, the same with the Lake district; these organic evidences of subsidences are only sporadic.

Nor must we hastily conclude that the subsidence was continuous. It may have been broken by pauses or partial re-emergences, and either of these would account for the presence of land and fresh-water remains in the Till.

Bearing all these facts and considerations in view, I am drawn to the conclusion that the bulk of the Lancashire Boulder-clays and sands are the marine equivalents of the Scotch Till. If not, I ask where are in Lancashire the equivalent deposits of the Till? It is not to be supposed, on any hypothesis, that during the confluent glacier or ice-sheet period deposits of great thickness were accumulated under the ice where the degradation was greatest, while on the far-off plains, to which the materials would naturally travel, no accumulation took place other than the small quantity of sand and rubble we find lying immediately on the rocks. Rather

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where the movement was slower and the friction greater, there would the accumulation occur, if occur it did under an ice-sheet.

It is quite possible that the ice-sheet shrunk towards the mountains before the subsidence of the land, and there is every probability that at the time of intensest cold the land was much more elevated than at present in relation to the sea. As the land subsided the glaciers or confluent glaciers deposited their burdens in the sea, either under and in front of them, while icebergs carried erratics to far-off deposits forming on the sea-bottom.

Thus looked at, the Scotch Till and the low-level Boulder-clays of the plains of Lancashire are continuous. They are, in fact, equivalent deposits in point of time, the one shading off into the other, the difference in their lithological constitution arising from the different conditions under which they were deposited, the weightier and more bulky materials remaining in larger proportion near their source, the finer muds being washed out to sea—the one becoming the stony Till, the other the semi-stratified, shelly Boulder-clay.

My remarks have extended to a greater length than originally intended, and, while expressing the very greatest respect and admiration for the splendid labours of Scotch geologists, I trust I may have presented the matter, not in a manner altogether opposed to their views, but in a somewhat broader aspect, leading to a modified and simpler explanation of glacial phenomena than the complicated and cumbrous geological reasoning often called in to explain exceptional facts. Of this I am sure, whether the views here propounded are true or false, or, as is more generally the case, amount only to partial truth, attention to geological facts other than those in our immediate district is the only way of arriving at correct conclusions.

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XXXIX.—*The* Geology *of* Dalry. By John Smith, Kilwinning, Corresponding Member.

[Read at an Excursion to Dalry on 7th June, 1879.]

At the bottom of the Carboniferous series, as developed at Dalry, are the lower limestones, separated from the calciferous sandstones by about a thousand feet of volcanic rocks, chiefly porphyrites and trap tuffs. The lower portion of these limestones is well seen at Auchenskeith and Auchenmade, and the upper portion at Auchenskeith, Auchenmade, Low Baidland, Thirdpairt, and near Birkhead, on the Caaf Water. The former is from 15 to 20 feet thick, and is of fair quality for agricultural, building, and furnace purposes; while the latter is from 20 feet thick at Auchenskeith, to 29 feet at Cunningham Baidland, and, in its higher part, flint bands and nodules of a lenticular shape are not unfrequent. In the Dalry district this limestone is all of inferior quality; while in the Beith district its upper portion is of very fair quality. Its total thickness is about 40 feet.

The next stratum of importance is the clayband ironstone, separated from the limestone by 27 fathoms of dark shales, in which occur a number of thin bands and balls of ironstone, and two or three beds of sandstone. It crops out along the bases of the hills, and it can be best seen at Giffartland burn, where it is on edge, and at the Pitcon burn, where it dips gently. The clayband seam of ironstone is very regular in thickness all over the district, being seldom less than 11, or more than 14 inches thick, and is now the backbone of the mining industry of Dalry.

Twenty-seven fathoms above the clayband is the position once occupied by the famous blackband ironstone, now all but extinct. All over the district are to be seen the large monuments of dark shale which have been raised to its memory. Unlike the clayband, it was very irregular; in the centre of the valley it sometimes reached a thickness of 27 inches; on the east, towards Highfield, Glencart, and Blair Castle, it dies out, its place being occupied by a thin seam of coal and a few nodules of ironstone. During its deposition there appears to have been considerable activity in the south-western part of the district, its place being often taken up by beds of volcanic ash. The blackband comes to the surface a

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little inside of the clayband out-crop, and the only place where it can now be seen is in the Hindog Glen. It lies distinctly in three beds—the middle portion might be called an agglomerate of small ironstone balls, in a paste of ironstone and tough shale.

Beds of dark shales with thin seams of ironstone and ironstone balls come in between the clayband and blackband ironstones, as well as two thick posts of sandstone, one of which is worked at Jameston and Ravenscraig. Between the blackband and the borestone coal are 38 fathoms of sandstones, shales, and thin bands of ironstone. The next 25 fathoms contain the regular coal-bearing strata of Dalry coal-field. None of these coals can be said to be of excellent quality, and the remarkable thing about them is that they are for the most part chiefly separated from one another by beds of sandstone. This brings us to the Highfield limestone, a calmy limestone of about 6 feet in thickness, well seen at Highfield, and near Bullerholes, on the Lugton Water. This is a good limestone for furnace, building, and farm purposes, and flies to pieces when put into a hot fire. Twenty fathoms above the last-mentioned, and separated from it by sandstones and shales, is another limestone about 3 feet thick, but of little importance. Twelve fathoms above this are 12 feet of inferior limestone, which can be seen in the Caaf Water, about quarter of a mile below Linnspout. Twelve fathoms of shales and sandstones bring us to the Linnspout limestone, which runs from 4 feet thick at Clonbeith to about 40 feet at Broadlie. It is all of very inferior quality, and useless, except for road metal. This limestone is well seen in Montcastle, Linn, and Broadlie glens, and is the footboard from which leap the beautiful little cascades to be seen in them. Thirteen fathoms of sandstones and shales and 12 fathoms of dolerite bring us to the base of the upper coal measures. Only some 12 or 15 fathoms of these are preserved in the Dalry field, and these form but a small patch near Pencoat, having been brought down opposite the trap tuffs below the lower limestones, by the large 200-fathom hitch which runs from Ardrossan by Dalgarvan, and up the valley of the Duisk Water.

All the limestones of the Dalry district are marine, there being, so far as I know, none of fresh-water origin. The lower limestones are very fossiliferous; the upper part especially so, as it is almost entirely built up of the remains of brachiopods, crinoids, polyzoans, corals, &c. Many fine fish remains have been got in

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them, belonging to such genera as *Psammodus*, *Pœcilodus*, *Ctenoptychius*, *Petalodus*, *Helodus*, *Petalorhynchus*, *Cochliodus*, *Polyrhizodus*, &c.; in the limestones there is almost a total absence of spiral and bivalve shells. Conodonts are found in both parts of the lower limestones, being not uncommon at Low Baidland and at Birkhead, on the Caaf Water. Sponge spicules are very abundant in the lower part of the upper post at Cunningham Baidland, Low Baidland, and Birkhead; although very rarely, these organisms are also got in the lower post. The shales in connection with the lower limestones have yielded a large number of good fossils, the presence of bivalves and univalves being more marked in some of them than in the limestones themselves.

A curious coincidence in connection with all the limestones of the Dalry district, and to which I beg to call your attention, is the fact that each of them has got a thin seam of coal about two or three feet below it, the intervening spaces being filled with shales containing fossils of a more or less estuarine type. The strata between the lower limestones and the clayband ironstone are probably of fresh-water or estuarine origin, but I have had little opportunity of examining them. The clayband ironstone is evidently a fresh-water deposit, the shales in connection with it holding the remains of *Rhizodus Hibberti* and other fishes and entomostraca, while the shales between the clayband and blackband ironstones are rich in *Lingula*, and may be of estuarine origin. The blackband was remarkable for its fine remains of lepidodendroid plants; it also contained a few fish remains and entomostraca. A single species of *Myalina*—not uncommon—and a *Nautilus* were the only shells I ever saw in this ironstone—rather an odd pair to be got together. The strata between the blackband and Highfield limestone shale, and in which the Dalry coals occur, are probably all of fresh-water origin. The Highfield limestone, though possibly of marine origin, contains almost no fossils. I have seen a stray *Productus* and an odd piece of *Alveolites* in the solid limestone, but beyond this few or no fossils occur. The shales in connection with it are rich in foraminifera, ostracoda, gasteropoda, and lamellibranchiata. Such genera as *Valvulina* and *Endothyra*, amongst the foraminifera; *Bairdia*, *Cythere*, *Beyrichia*, and *Leperditia*, amongst the ostracoda; *Macrocheilus*, *Naticopsis*, and *Pleurotomaria* amongst the gasteropoda. Lamellibranchs, such as *Leda* and *Nucula* and the heteropod *Bellero-*

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phon, are common. The strata between the Highfield and the next limestone are probably all of fresh-water estuarine origin.

The three-feet limestone contains few organic remains, while the twelve-feet limestone has a few, and the shale below it is very rich, being one of the best for microzoa I have ever examined. The crustacean *Griffithides Eichwaldi* is not uncommon in this shale. We now come to the Linnspout limestone, some of the beds of which are very rich in organic remains, the trilobite *G. mesotuberculatus* prevailing much, while such brachiopods as *Productus*, *Rhynchonella*, *Athyris*, *Camarophoria*, *Spirifera*, *Strophomena*, and *Terebratula* are not uncommon. The shale beneath it is also very fossiliferous—*Arca*, *Axinus*, *Leda*, and *Nucula* being frequent bivalves. Spirals, such as *Pleurotomaria*, *Machrocheilus*, *Natica*, and *Bellerophon* are common. In this shale is a thin band filled with the phyllopod crustacean *Estheria punctatella*.

The largest hitch or fault in the Dalry district is the 200-fathom dyke before referred to. At one part it brings down the lower portion of the upper coal measures opposite the upper part of the volcanic rocks which separate the lower limestones from the calciferous sandstones. As may be seen from the Geological Survey Map, the district is pretty much faulted all along the western portion of the field, while between this and the Duisk valley hitch several cross-hitches occur. Between the calciferous sandstones and the lower limestones, porphyrites and trap tuffs occur, and at Baidland they are about 1000 feet in thickness. They thicken towards the north and thin away towards the south. In the western portion of the field, as well as at Dockra, Hillhead, and Waterland, in the Beith district, a bed of volcanic ash tops the upper part of the lower limestone. This ash-bed contains great quantities of minute fish remains, and at Hillhead foraminifera are very common. Sigillaria roots are frequent in this ash, as well as in the top portion of the limestone itself. In the south-west portion of the field at Langlands the distance between the black-band ironstone and the Highfield limestone is almost entirely occupied by ash-beds, and all the other strata are wanting. This great accumulation of ash, about 100 fathoms in thickness, is local, but some of the tail-pieces of this ash-bed extend as far as Dalry Station. In one of these above the "wee" coal a splendid specimen of *Dadoxylon*, showing structure, was got.

The next great accumulation of igneous rocks are the dolerites

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that come in between the sandstones which overlie the Linnspout limestone, and the base of the upper coal measures. In the Dalry district these dolerites are about 12 fathoms thick, and occupy about 4 square miles of surface area. They are well seen in the Blair and Montcastle estates.

In the valley of the Garnock Water, towards the north part of the field, the Boulder-clay is sometimes as much as 70 feet in thickness, and thins away towards either side of the valley. It is in two parts, as can be distinctly seen in the railway cutting below Dalry Station. The lower part is a bluish, tough, stony deposit; the upper is not so firmly put together, and is lighter in colour. The great majority of the contained boulders and stones are of local origin, whilst a number of them have evidently been brought from long distances. The movement of the ice seems to have been from N.E. to S.W. A splendidly striated surface is to be seen at present on the dolerite near Blair House. On the top of the Boulder-clay, near Lintseed ridge, is 40 feet of mud, which evidently holds the place of a filled-up lake.

The strata, as seen in the glens, quarries, and pits of the Dalry district, exhibit sections from which the palæontologist and physical geologist may derive a considerable amount of interest and instruction. The section of the Carboniferous rocks may be said to commence with a thin seam of coal, and there are 23 seams (not including those of the upper coal measures), with their underlying fire-clays, which show that during the deposition of the Carboniferous strata of this district there have been as many land surfaces, or, more probably, extensive swamps. It appears to me that the plants which went to build up the coal-beds had the power of growing with their roots and part of their stems in water. If this was not the case, it is difficult to account for the large quantity of clay and the frequent partings of shale in all the Dalry coals.

The shales in connection with the limestones speak of estuaries in which swarmed myriads of animals belonging to protozoan, polyparian, molluscoid, and crustacean types, and into which large quantities of mud were carried by a great river, flowing probably from the north-west. The lower limestones appear to have been built up at the bottom of moderately-deep seas, whose clear waters were occasionally darkened by mud, and where swarmed the lords of the then world, the sharks of the period; and where

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brachiopods and crinoids, polyzoans and corals, flourished in abundance. The Highfield limestone shows an ocean holding excess of lime in solution, part of which was precipitated in the form of finely-divided limey mud, and which is now seen as calmy limestone. The ironstones speak of quiet waters, into which volcanic ashes were sometimes thrown, and where iron was being deposited as a clayey carbonate. There are 30 bands of ironstone in the district, 28 of which are too much divided among themselves—too schismatic, in fact—to be of any effect in the affairs of the world. The upper limestone tells us of a shallow sea swarming with brachiopods and crustaceans, liable to be darkened by inflows of mud, and in which encrinites and corals never attained dominion. The sandstones, with their ripple-marks, point to sandy beaches, where the branches and trunks of trees were often stranded, and where the great rain-drops from the dark bosom of the thunder-cloud pattered, leaving their sign manual for our instruction.

Of the strength of volcanic activity in this district, we have ample evidence in the 1000 feet of porphyrites and trap tuffs which come in between the calciferous sandstones and the base of the lower limestones; in the 600 feet of volcanic ashes which occupy the space between the blackband ironstone and Highfield limestone in the western part of the field, and in the 12 fathoms of dolerites which separate the sandstones above the Linnspout limestone from the base of the upper coal measures. At the present time we again hear of Etna shaking itself, and sending forth showers of ashes and streams of lava. It is not impossible that at some future time the slumbering fires of Dalry may again be stirred into activity, and deluge the hills and plains with showers of heated dust and stones, and with streams of molten rock.

The lower part of the Boulder-clay, on the other hand, speaks to us of a long period of intense cold, when the whole country was submerged under ice and snow. The upper portion of the same deposit tells us of the time when the ice was melting from the face of the country, then considerably below sea-level, and when large icebergs deposited their carried burdens of rock and mud, upon the bottom of the ocean.

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PROCEEDINGS FOR SESSION 1878-9.

(21st Session.)

SOCIETY'S ROOMS, ANDERSON'S COLLEGE.

10th October, 1878.

Mr. John Young, F.G.S., *Vice-President*, in the Chair.

The Chairman congratulated the members on once more assembling to begin the work of a new session, and expressed a hope that the labours of the winter would prove both pleasant and profitable, and that the papers and other material brought before the meetings would worthily maintain the reputation of the Society.

Messrs. R. M. Cairney, Mathew Clark, D. M'Millan, and John Adamson were elected Ordinary Members.

Mr. Walter Burns exhibited a series of Rolled Chalk Flints, which he had found in the course of the past summer in the drift beds of the Ayrshire coast, near the Heads of Ayr, at an elevation of about 20 feet above the present sea-level; also, a Flint Flake, from a quarry in the same neighbourhood.

The Chairman stated that this collection possessed extreme interest, as flints had not been previously found in quantity in Ayrshire. No doubt they were originally derived from the Cretaceous strata of the North of Ireland. The flake, or knife, closely resembled some of those found by Mr. Christie in the caves of Perigord, in France. In connection with this subject he mentioned that an extraordinary find had been lately made by a member of the Society in Ayrshire—hundreds of flint knives, arrow-heads, &c., evidently on the site of a manufactory of flint implements. The locality could not at present be stated, but the finder intended to bring his discovery before the members as soon as he had worked it out fully.

Mr. John Kirsop exhibited, through the kindness of Mr. Gillespie, Inspector, a Horn of *Bos longifrons*, the extinct Long-fronted British Ox, attached to a portion of the *os frontis*, which had been dug up at the junction of High Street and Duke Street, where excavations were lately being made for water-mains. It was lying about nine feet below the surface, in a bed of gravelly sand about two inches thick. Being attached to the skull, it was evidently not a shed horn.

Mr. Arthur Pratt read Notes descriptive of the preparation of Rock Sections for the Microscope, giving a lucid description of a method discovered by himself, and to the success of which hundreds of slides of volcanic rocks on the table amply testified. [See vol. vi., part i., page 61.] Before and after the meeting many of the members inspected them, with evident appreciation of their beauty.

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Mr. MURDOCH then read a paper by Dr. James Geikie, F.R.S., &c., of H.M. Geological Survey, entitled "Notes on the Geology of Colonsay and Oronsay" [see page 157], illustrated by a map of the islands.

The CHAIRMAN said he agreed generally with the conclusions of Dr. Geikie's paper, although it must not be forgotten that on some points—as, for example, the origin of the metamorphic rocks—authorities were far from being at one.

Mr. JAMES THOMSON, F.G.S., said he could not agree with some of the points stated by the writer. The dip and strike being coincident with those of the neighbouring islands, where the strata were principally Laurentian, he had therefore no doubt that the rocks of Colonsay and Oronsay belonged to that formation.

7th NOVEMBER, 1878.

ANNUAL GENERAL BUSINESS MEETING.

Mr. DAVID SANDEMAN, *Vice-President*, in the Chair.

Mr. MURDOCH read the Report of the Council on the past Session, 1877-78, as follows:—

AT the commencement of the Twenty-first Session of the Geological Society of Glasgow, the Council beg to submit their Report for the past year.

THE MEMBERSHIP of the Society continues to be well maintained. The number of names on the Roll reached 228—the life members 21, the honorary members 11, the honorary associates 8, the corresponding members 23. During the year only 13 new members joined—a number much below the average of former years. In connection with this fact, the Council would impress upon members that new recruits are continually needed, as a certain loss must be looked for every year, either by death or desertion, which, if the Society is to preserve its efficiency, must be met, and more than met. The financial position is, no doubt, at present satisfactory, but should there be a change in the place of meeting, a considerable addition to rent, library accommodation, &c., will require to be faced.

It is thought well to bring prominently under the notice of members one item of the Treasurer's statement. The delivery of copies of *Transactions* to town members and the cost of collecting unpaid subscriptions reached during this year the heavy amount of nearly £9. Much of this tax on the Society's funds would be saved if members would promptly take up their publications as soon as ready, and pay subscriptions when due. The latter will be in the present year more than ever necessary, as the free funds of the Society are locked up in the City Bank, and money will now be required for current expenses.

THE MEETINGS of the Session were well attended. As in past years, a number of valuable papers were read and discussed, and many specimens of interest were exhibited, with remarks, more or less detailed.

Sir William Thomson gave a presidential address "On the Internal Condition of the Earth, as to Temperature, Fluidity, and Rigidity." Dr.

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Lauder Lindsay, of Perth, contributed two papers "On the Alleged Discovery of Gold Quartz in Lanarkshire;" and Mr. Charles Lapworth, F.G.S., of St. Andrews, read an important paper "On Recent Discoveries among the Silurians of South Scotland."

As of late years, the Council did not arrange for any special or systematic lectures, those of the Glasgow Science Lectures series on the one hand, and the Geological course by Mr. John Young, F.G.S., in the Mechanics' Institution on the other, amply providing for any wants in these directions.

THE EXCURSIONS of the year were as follows:—

April 13.—Busby, Braehead, and Thornton Hall Quarries, conducted by Mr. James Neilson, jun.

,, 27.—Strathblane, Mugdock, and Milngavie, conducted by Mr. John Young, F.G.S.

May 11.—High Blantyre, conducted by Mr. D. C. Glen, F.G.S.

,, 18.—Mid-Calder, Camps Quarries—Meeting with the Edinburgh Geological Society—conducted by Mr. James Melvin, V.P., Edin. Geol. Soc.

,, 24 (Queen's Birth-day Picnic).—Tillietudlem, Craignethan Glen, conducted by Dr. John R. S. Hunter, Braidwood.

June 8.—Dalry, conducted by Mr. Robert Craig, Langside, Beith.

For reasons only known to the clerk of the weather, several of these days were amongst the worst of the season, the excursions being consequently either abandoned altogether or conducted under great difficulties. This remark could not, however, apply to the excursions to Mid-Calder and to Tillietudlem—the former a joint-excursion with the Edinburgh Geological Society, a most enjoyable day, and, the Council hope, not the last of such meetings with kindred societies; and the latter, the Queen's Birth-day annual picnic, which, amongst the beautiful and romantic scenery of Craignethan Glen, was by no means the least successful of similar outings. On this occasion Dr. John R. S. Hunter, of Braidwood, acted as conductor, reading a most interesting paper on the history of the old Castle and on its Geological surroundings [see vol. vi., part i., p. 84]; and to him and all the other conductors of the various excursions the thanks of the Society are due.

THE LIBRARY.—The Librarian reports that exchanges continue to be made with a number of home and foreign Societies, but, with these exceptions, there have been very few additions to the stock of books. Now that the funds of the Society are in an improved condition, it is intended to add some new works in Geological science, and the Council hope that an increased number of readers will avail themselves of the advantages offered by the Library.

THE MUSEUM.—As regards the collection of specimens in the possession of the Society, not much can at present be said. Owing to the want of accommodation, caused by the change in the rooms occupied by the Society, only a few of the cases are accessible, these being shown in the Museum of Anderson's College. The others are, in the meantime, in store.

PUBLICATIONS.—The second part of vol. v. of the *Transactions* of the

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Society was issued last January, and seemed to be much appreciated, containing, as it did, a number of valuable papers—notably one by Sir William Thomson, which was illustrated by a beautiful map of the Arctic regions, engraved by Messrs. W. & A. K. Johnston, of Edinburgh.

The first part of vol. vi., now printing, will find its way, the Council hope, into the hands of members during the present winter. It will include the work up to the end of the session 1877-8.

In conclusion, the Council would express a hope that the harmony and good feeling so long existing in the Society will continue unbroken, and that every member who can contribute facts, however small, to the common stock will not hesitate to do so, assured, as each one may be, of a cordial welcome and an attentive hearing.

The Treasurer read his Report, as follows:—

The total income of the year just ended is £117 12s. 10d., that of the preceding year was £123 16s. 10d., showing a difference of £6 or thereby against the present year, but, on the whole, a sufficiently favourable account of the Society's normal income. The ordinary subscription income is £6 higher, and life subscriptions £5 5s. lower. The expenditure, however, is more than £6 lower than last year, so that the Society's income and expenditure may be said to continue to be favourable. Besides, the current debts outstanding last year were given up at £40 17s., while this year they are only £18 8s. 1d., per certificate furnished by the Secretary.

The Treasurer estimated the subscriptions to be £110 10s., representing 221 members, besides the new members. The amount collected has been £106, including £6 10s. for 13 new members. This shows that 22 old members have failed to pay, either from resignation or some other cause.

The current liabilities consist of £2 17s. 3d. for printing; £8 8s. 6d. for engraving; rent, £5; carriage, £1 1s. 4d.; and subscription to Palæontographical Society, £1 1s.—in all, £18 8s. 1d.

The Society's Collector cannot undertake to collect the subscriptions in future for a commission of less than 7½ per cent.

It will be observed that publications sold have only recouped the expenditure of printing Dr. Geikie's paper to the extent of £14 14s., which is scarcely one-half its cost.

It may be doubted, from present appearances, whether the Society will be able to show so good a Balance-sheet at the close of the financial year just about to commence.

The Treasurer's Financial Abstract will be found at page 305.

Both the Report of the Council and that of the Treasurer were unanimously approved of and passed.

The vacancies in the list of Office-Bearers were then filled up, as follows:—Mr. D. C. Glen, F.G.S., Vice-President; Messrs. John Young, F.G.S., D. Wilson, Thos. Naismith, Walter Burns, Thomas King, Members of Council (Mr. King being elected for only one year); Mr. John Wight, C.A., Treasurer; Mr. R. Neilson, Librarian; Mr. Jas. B. Murdoch, Secretary and Editor of *Transactions;* Mr. Gavin Pratt, Joint-Secretary.

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The CHAIRMAN exhibited from his own collection a series of minerals and metallic ores, of which he gave short descriptions. (1) Variegated Sandstone from the Isle of Wight, showing examples of false bedding, and curious staining of the rock by oxides of iron. (2) Rock Salt from the Cheshire mines, which he had visited, and of the mode of working which he gave a short account, the effect produced in the galleries of the mines when illuminated by coloured lights being very beautiful. (3) Oil Shale from West Calder, used in distillation of paraffin and other products. He described a recent visit to one of the pits in the district, at a depth of 600 feet, where a cutting machine was at work excavating the shale. The oil shale lies in the Calciferous sandstone series of the Scottish Coal Measures, and is of varying thickness and quality, having a strong clay basis, like the celebrated Torbanehill mineral. It is, however, far inferior to it for oil and paraffin-producing purposes, but, being found in much thicker beds, it is extensively worked in the West Calder district. (4) A rich Argentiferous Galena, with yellow cubical iron pyrites, from Tuscany. (5) Crystallized Hematite, or Specular Iron Ore, from Elba.

Mr. JOHN YOUNG, F.G.S., made some further remarks on the specimens exhibited by Mr. Sandeman, referring to their chemical composition, their industrial value, and the geological position of the strata from which they were derived.

Mr. YOUNG also exhibited, from the Kilmarnock coal-field, a slab of Black Septariated Carboniferous Shale, in which the shrinkage cracks or septa were filled up with Marcasite, a variety of iron pyrites. It showed very distinctly the manner in which the various septa had been formed at distinct intervals, there being at least four distinct groups, the newer ones never cutting through the older. The largest septa were about a line in width, dwindling down from that to thin threads, and, as they were of a rich yellow colour, and traversed the stone in all directions, a fine effect was produced on the black ground of the shale.

Mr. JOHN KIRSOP exhibited a polished specimen of the Dolomite, or Magnesian Limestone, of Sunderland, which illustrated in a beautiful manner the formation from chemical segregation of this peculiar bed of limestone, being composed of tube-like layers, which gave it quite a coralline-looking structure. Mr. Kirsop also showed a small glaciated boulder of schist from Bute, on the surface of which the striæ were well seen.

Mr. ARTHUR PRATT made some remarks upon a fossil Echinoderm which had been sent him from Kirkcaldy, Fifeshire. As he was in the hope that it had come from the Carboniferous limestone of that district, he was inclined to refer it to *Palæchinus*, a genus not yet satisfactorily determined to occur in the Scottish limestones. On closer examination, however, the specimen, which was filled with a dark-grey flint, proved to be an example of *Ananchytes ovatus*, a well-known Cretaceous species, which had in all probability been brought to Kirkcaldy with the Chalk limestone used at some of the manufactories there.

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5th DECEMBER, 1878.

Mr. JAMES DAIRON, *Vice-President*, in the Chair.

The Rev. Alexander Stewart, F.S.A.Scot., of Ballachulish, was elected a Corresponding Member. Messrs. Neil D. Cochrane, Robert Livingstone, David Ross, B.A., B.Sc., William Young, James Beveridge, and Thos. A. Connell were elected Ordinary Members.

Mr. JOHN YOUNG, F.G.S., exhibited specimens of several of the mineral species of the simple hydrocarbons belonging to the Paraffin group. Two of these, Ozokerite and Urpethite, from the clayband ironstone series of Dalry, Ayrshire, were new to Western Scotland, having only recently been discovered in the working of No. 9 pit, at Glencart, on the Blair estate, and sent him by Mr. John Smith, of Kilwinning. Only one other locality for Ozokerite has been recorded for Scotland—viz., Uphall, in Linlithgowshire—and specimens from that district were also shown. The Ozokerite from Glencart is of a yellowish and yellowish-brown colour, having about the hardness and consistency of beeswax, and melts at a very low temperature into a clear yellow oil, which on cooling returns to its normal colour. The Ozokerite from Uphall is of a dark brown colour, is harder than the Glencart variety, and melts into a dark, brownish-black oil. It is almost identical in colour with specimens from the blackband ironstone of the Lugar coal-field, which is a second locality for the mineral in Ayrshire.

The Urpethite from the Glencart pit is of a deep black colour, probably due to impurities of carbonaceous matter in the form of soot. It is softer than tallow, and can be kneaded by the hand, but sticks to the fingers. It melts at a very low temperature into a black oil, which on cooling resumes its former black, tallowy consistency. Urpethite was first found in the working of the Urpeth Colliery, in England, where it occurs combined with a certain amount of Ozokerite, and this is likely to be the case with that found at Glencart. Both these minerals are supposed to have been distilled through the action of heat from the bitumenous strata in which they occur, and in which they are found filling cavities and fissures.

Mr. YOUNG also exhibited specimens of Elaterite—another mineral of the Paraffin group—from the Carboniferous limestone of Castleton, Derbyshire. It is also known as Elastic Bitumen or Mineral Caoutchouc, and has been found in one or two Scottish localities in the Carboniferous system. It is of a brown colour, soft, elastic, adheres slightly to the fingers, does not melt at 205° C., and burns in the flame of a candle. The melting point of Ozokerite being 60° C., and that of Urpethite 37° C., Elaterite therefore differs from them materially in this respect.

Mr. JOHN MAYER, F.C.S., exhibited specimens of Ozokerite from Galicia, forwarded by Messrs. Field, of London, who use it largely in the manufacture of candles.

Mr. E. A. WÜNSCH, F.G.S., read a paper, entitled "A German Professor's Views of the Geology of Arran, translated from Prof. A. von Lasaulx's 'Aus Irland,' Bonn, 1878, with Remarks." [See page 165.] Owing to the lateness

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of the hour, Mr. Wünsch's own views and comments were postponed till the following meeting.

Mr. JAMES THOMSON, F.G.S., and Mr. JOHN YOUNG, F.G.S., both objected to Prof. von Lasaulx' theory as to the origin of the granitic nucleus of Arran.

16th JANUARY, 1879.

Mr. JAMES DAIRON, *Vice-President*, in the Chair.

Messrs. W. L. M'Ewan and G. L. M'Pherson were elected Ordinary Members.

Mr. HUGH RIDDELL exhibited a fine series of Fossil Woods from Antigua. In all the specimens the organic matter had been replaced by silica, particle by particle, so exactly, that in microscopic sections of some of them which had been made by Mr. Arthur Pratt, their minute and complicated structure was so distinct that identification of the wood was a matter of no difficulty.

The CHAIRMAN (Mr. Dairon) read a paper "On the Rocks and Graptolitic Shales of the Moffat District." [See page 178.] The paper was illustrated by a fine series of specimens.

Mr. JAMES THOMSON, F.G.S., read a paper "On the Geology of the North End of Arran."

Owing to the length of the business, discussion on these papers was postponed till next Meeting.

6th FEBRUARY, 1879.

Mr. JAMES DAIRON, *Vice-President*, in the Chair.

Mr. E. A. WÜNSCH read his postponed remarks upon Prof. von Lasaulx' 2nd Chapter on Arran, of which he had read a translation at the December meeting, and gave his own theory as to the origin of the Arran granites. [See page 175.]

Mr. JOHN YOUNG, F.G.S., reviewed the question, and said that he could not agree with Mr. Wünsch in saying that all granite was or ever had been a stratified rock. As had been pointed out by Prof. Ramsay in his "Geology of Arran," granite occasionally assumed a bedded or stratified appearance, as indeed did other rocks of undoubted volcanic origin. He had himself no doubt whatever that the Arran granite was a strictly eruptive rock.

Mr. JAMES THOMSON, F.G.S., said he could not accept Prof. von Lasaulx' theory regarding the Arran granites. He had found, in all the sections exposed around the granite nucleus, the stratified rocks uptilted to angles, indicating not only great eruptive force, which had shattered them, and produced lateral fissures afterwards filled up with the injected granite, which had all the indications of having been in a hot and fluid state—for not only were the fissures filled, but the granite passed from coarse into fine-grained. When the granite came in contact with the surrounding stratified

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rocks the crystalline aspect was much altered, and in every way they resembled stratified rocks in other parts of the country which had been affected by igneous action of later date. In confirmation of his opinions, Mr. Thomson described the appearances presented in various districts where the granites were recognised as being of eruptive origin. He referred to those of the West Highlands, Galloway, Devonshire, Galway, Wicklow, and the Mourne mountains, and said that in all these districts the stratified rocks were similarly affected to the way they were in the vicinity of undoubted igneous eruptive rocks throughout Scotland. He was therefore obliged to conclude that the Arran granites were strictly eruptive, but whether the granite was derived from stratified rocks metamorphosed by hydrothermal action was a question he was not prepared to decide. He could not hope to have a satisfactory solution of the origin of granite until more exhaustive investigations were obtained, both microscopical and chemical, as to the granite and granitoid rocks of the world.

Other members having spoken,

Mr. Wünsch, in reply, said he did not believe that granite had ever been in a state of fusion, nor was there the slightest evidence to show the existence of a volcano in Arran, nor was anywhere in Scotland such a thing as a volcanic vent in granite. There was no use in quoting text-books for one theory or another, as authors were in a state of complete disagreement on the subject.

Mr. Thomson then shortly reviewed his paper on Arran, read at the January meeting, and a short discussion followed. He then read a paper, entitled "On the Modes of Reproduction in Corals," which was illustrated by a fine series of specimens. Its termination had to be postponed till the March meeting from want of time.

6th March, 1879.

Mr. D. C. Glen, F.G.S., *Vice-President*, in the Chair.

Mr. Thomas Barr, C.E., called attention to the fact that the Society was now on the eve of attaining its majority, and suggested that a special commemorative meeting should take place in October next.

Mr. Sandeman moved that it be remitted to the Council to make arrangements for carrying Mr. Barr's suggestion into effect, and this was unanimously agreed to.

Mr. David Robertson, F.L.S., F.G.S., exhibited an interesting series of Crystallized Dolomitic Limestones, which he had collected from the Magnesian Limestone series of Sunderland. The specimens illustrated the various forms which this curious formation of limestone has assumed when passing from the sedimentary into the semi-crystalline condition, through the action of what is known as chemical segregation. Amongst them were fine examples of the botryoidal, mammilated, stalactitic, coralloidal, and honeycomb varieties, many of them showing clear evidences of having been segregated into their present forms out of finely-laminated

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horizontal strata. Mr. Robertson said he had presented this interesting series of specimens to the Hunterian Museum, Glasgow University, where they could at any time be studied by those interested in geological science.

The CHAIRMAN (Mr. Glen) also exhibited specimens of Dolomitic Limestones from various localities.

Mr. JOHN KIRSOP sent for exhibition a well-preserved grinding tooth of the Mammoth (*Elephas primigenius*), found by Mr. Robert Bethune, contractor, about four years ago, when sinking a pit on Mainhill farm, near Baillieston, east of Glasgow. In the absence of Mr. Kirsop, Mr. John Young described this interesting specimen. Mr. Bethune had stated that this pit lies about 700 yards east of the village of Baillieston, and 200 yards south of the Coatbridge and Baillieston road. The tooth was found in a bed of finely-laminated sandy clay at a depth of 33 feet below the present land surface, the sand-bed being from 40 to 45 feet thick, and resting directly upon the rock-head or coal measures, without any intervening Till or other superficial strata. Mr. Bethune had also stated that, in cutting the line of railway leading to the pit, the sand-bed was seen to be overlapped by a thick bed of stiff dark-coloured Boulder-clay full of large travelled stones, which thinned away as the pit was approached and the sand-bed rose to the surface. Mr. Young said that Mr. Bethune seemed to be a careful observer of geological phenomena, and that, from his clear statements, he had no doubt whatever that here we had another instance of the occurrence of the Mammoth in Scotland during pre-glacial times. He was inclined to agree with Prof. Boyd Dawkins in the opinion expressed in his recent paper in the *Quarterly Journal* of the Geological Society, 1879, "On the Range of the Mammoth in Space and Time," that all the recorded instances of its occurrence in Scotland were in favour of its pre-glacial appearance there; rather than with the view expressed by Dr. James Geikie in his "Great Ice Age," 1876, that the Mammoth was inter-glacial in its appearance in Scotland. Mr. Young proceeded to name the few Scottish localities where remains of the Mammoth had been found, and stated that they had in these instances been obtained either from pre-glacial beds below the Till or in the Till itself. Dr. Geikie had never been able satisfactorily to show that his Mammoth-bearing inter-glacial beds, in any of the places where they have been found, rested on an older Boulder-clay, although he says that at other spots, such as Kilmaurs, intercalated beds are found in the same district between the two Tills; but, unfortunately for his contention, these beds have never as yet yielded any Mammoth remains, nor any of the other organisms usually found associated with them. Where traces of the Mammoth have been got in Boulder-clay, they may in all probability have been derived from the denudation of pre-glacial beds in the same district.

Mr. JAMES NEILSON, jun., exhibited specimens of Macrura, a family of decapod crustaceans characterised by the large size of the tail, as in the common lobster, and distinguished from the Brachyura or short-tailed, like the common crab. Both families are found in Secondary and Tertiary strata, but in the Palæozoic rocks only the Macrura have been as yet discovered. These specimens were from Lanarkshire.

Mr. DAVID SANDEMAN, V.P., exhibited a specimen of Slag Wool, an

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artificially-formed fibrous preparation of Slag, possessing the property of being perfectly incombustible, and being thus well suited for covering boilers and pipes, where there is great exposure to heat. Its marketable value being from 11s. to 23s. per ton, according to quality, if it came, as was expected, largely into use, the unsightly mounds of Slag which in many places covered the ground would soon disappear.

Mr. JAMES THOMSON, F.G.S., then resumed his paper "On the Reproduction of Corals," illustrating it with many fine sections of genera and species from Carboniferous strata.

10th APRIL, 1879.

Mr. DAVID SANDEMAN, *Vice-President*, in the Chair.

Mr. E. A. WÜNSCH, F.G.S., moved a vote of condolence on the death of Dr. David Page, F.G.S., the Society's old friend and teacher, and in an interesting and feeling address reviewed his life and work. [See page 182.] It was seconded by Mr. John Young, F.G.S.

Mr. JAMES THOMSON, F.G.S., said that he believed the members of the Society were more indebted to Dr. Page's writings for the geological knowledge they possessed than to those of any other author.

The CHAIRMAN (Mr. Sandeman) proposed, and Mr. YOUNG seconded, a motion that the Secretary should send an extract from the minutes to Dr. Page's widow and family, which was unanimously agreed to.

Mr. JOHN SMITH, Kilwinning, Corresponding Member, read a paper "On the Occurrence of Flint Nodules and Worked Flints in the Post-tertiary Sands of the Ayrshire Coast, between Saltcoats and Troon" [see page 185], illustrating it with a large and beautifully-arranged series of examples.

Mr. YOUNG, Mr. THOMSON, Mr. MURDOCH, and Mr. WALTER BURNS made some remarks on the subject.

Mr. JAMES C. CHRISTIE read a paper on "A Visit to the District of the Eifel and its Volcanic Rocks" [see page 192], which he illustrated by a large suite of specimens. Owing to the lateness of the hour, the latter portion of Mr. Christie's paper had to be postponed till the following meeting.

1st MAY, 1879.

Mr. JAMES DAIRON, *Vice-President*, in the Chair.

Messrs. Peter Dunn, David Johnston, Peter Mackay, and Thomas Steel were elected Ordinary Members.

The CHAIRMAN (Mr. Dairon) read a paper entitled "Note on the Reproduction and Development of Graptolites." [For an Abstract, see page 206.]

Mr. JAMES C. CHRISTIE read the continuation of his paper "A Visit to the Eifel and its Volcanic Rocks," postponed from last meeting.

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On its conclusion, Mr. E. A. WÜNSCH, F.G.S., made some remarks complimenting Mr. Christie upon his *début* before the Society, and corroborating many of his statements, which he was able to do from a personal knowledge of the district spoken of.

Mr. JAMES THOMSON, F.G.S., read "Notes on the Metamorphic Rocks of Harris and North Uist." [For an Abstract, see page 207.] The paper was illustrated by a large series of rock specimens from Harris and neighbouring localities.

The CHAIRMAN, Mr. YOUNG, and others, made some observations on the subjects referred to in Mr. Thomson's paper.

15th MAY, 1879.

Mr. D. C. GLEN, F.G.S., *Vice-President*, in the Chair.

Mr. JAMES NEILSON, jun., exhibited an extensive series of Scottish Carboniferous Brachiopoda, comprising representatives of nearly every species as yet recorded, some of them new to Scotland. [For his remarks, see page 209.]

Mr. JAMES THOMSON, F.G.S., spoke in high terms of Mr. Neilson's collection.

Mr. THOMSON then read "Notes on Fossil Sponges from the Carboniferous System, with Remarks on their Stratigraphical Distribution."

Mr. MURDOCH explained the arrangements made for visiting the Pentland Hills, in company with the Edinburgh Geological Society, on 14th June; and Mr. YOUNG described the district to be gone over, also the Bridge of Allan district, which was to be the scene of the Queen's Birth-day excursion, on the 22nd of May.

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PROCEEDINGS FOR SESSION 1879-80.

(22ND SESSION.)

SOCIETY'S ROOMS, ANDERSON'S COLLEGE.

9th OCTOBER, 1879.

Mr. D. C. GLEN, F.G.S., *Vice-President*, in the Chair.

Mr. WALTER BURNS exhibited a number of Fossils which he had collected during the summer from the Calciferous Sandstone beds near the Heads of Ayr, comprising Spines, Scales, and Teeth of Fish, also Molluscan and Plant remains. These beds are undoubtedly of estuarine or fresh-water origin, and much resemble those found on the Fife coast, near Leven. As in that locality, the strata are principally exposed below high-water mark, and are partially covered with sand; but, if the series could be thoroughly followed out, they would be probably found to alternate with marine strata.

Mr. JOHN YOUNG, F.G.S., Mr. JAS. NEILSON, jun., and others made remarks upon Mr. Burns' collection.

Mr. JOHN KIRSOP exhibited a fine series of specimens of Gold Quartz, from the Wynaad gold-field of Southern India, and which appeared to be extremely rich in the precious metal. Mr. Kirsop also exhibited specimens of Pectolite and Calcite—the latter in the shape of a magnificent stalactite from a cave in Cuba.

Mr. ROBERT MASON exhibited a fine specimen of Chalcanthite, or Native Sulphate of Copper, from the Tharsis Mines, in Spain.

Mr. THOMAS STEEL exhibited a series of Fossil Shells and Crustacean remains, from the Post-tertiary beds cut through during the excavation of the new Docks at Garvel Park, Greenock, and from which locality many specimens had been obtained by members of the Society several years ago, during the progress of a previous excavation.

Mr. JOHN YOUNG, F.G.S., read a paper, entitled "Notes on the Perfect Condition of the Cell-pores and other Points of Structure in certain species of Carboniferous Polyzoa, from Western Scotland." [See page 211.]

Mr. JAMES THOMSON, F.G.S., afterwards made some remarks on the subject.

13th NOVEMBER, 1879.

ANNUAL GENERAL BUSINESS MEETING.

Mr. D. C. GLEN, F.G.S., *Vice-President*, in the Chair.

Dr. J. R. S. Hunter was elected an Honorary Member, and Messrs. W. W. Blackie, J. Dalrymple Duncan, John Farquhar, Alex. M. Graham, and Thos. L. M'Kim were elected Ordinary Members.

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Mr. MURDOCH read the Report of the Council for the past Session, 1878-79, as follows :—

At the commencement of the Twenty-second Session, the Council take the renewed opportunity of laying before the members their Annual Report on the work of the past year. The Society has at this date attained its majority, and it is now under consideration how most fittingly to commemorate the auspicious occasion.

MEMBERSHIP.—The Council are happy to say that the membership has been only slightly affected by the great commercial depression of the last two years, and that it still stands higher than the average of three years ago. They hope, however, that members will not forget recruits are always needed to fill the ranks, thinned from time to time by death and desertion. The names on the roll number 210. During the year 12 new members were enrolled, but no additional life members were added to the list.

THE MEETINGS of the session were well attended, and the business brought forward, whether in the shape of papers, or specimens with explanatory remarks, was of considerable value and interest. Copious reports of most of the meetings appeared in the *N. B. Daily Mail*, to the editor of which paper thanks are consequently due. There were no special meetings, and no presidential address was given, as Sir William Thomson's time was much occupied; but the Council hope that the President will be able to address the Society in the course of the present session. Mr. Lapworth, of St. Andrews, and Dr. Traquair, of Edinburgh, both arranged to read papers before the Society, but had to postpone them till a future occasion.

THE EXCURSIONS of the season were as follows :—

April 12.—Busby, conducted by Mr. James Neilson, jun.
,, 26.—Corrieburn, conducted by Mr. John Young, F.G.S.
May 10.—Milton of Campsie, conducted by Mr. Daniel Wilson.
,, 22.—(Queen's Birth-day.)—Bridge of Allan, conducted by Mr. Murdoch.
June 7.—Dalry, conducted by Mr. John Smith.
,, 14.—The Pentland Hills—Meeting with the Edinburgh Geological Society—conducted by Mr. Henderson, Edin. Geol. Soc.
June 21.—Beith, conducted by Mr. Robert Craig, Langside, Beith.

During several of these the weather proved very unpropitious, which interfered with their success, but the others were more successful, and there were good musters. The excursion to the Pentland Hills, in concert with the Edinburgh Geological Society, was perhaps the most noticeable, from its taking a line of country new to almost all the members of the this Society, and, except that the conductors essayed too extended a walk, it proved a success. It will, of course, be the duty of your Council to invite the Edinburgh Geological Society to visit Western ground during next spring or summer. Thanks are due to all the gentlemen who were kind enough to act as conductors.

THE LIBRARY remains without change in its main features. Not nearly

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so many of the members take advantage of the books as should be the case, which possibly may to some extent be accounted for by the fact that, except the *Proceedings* and *Transactions* of other societies, no new works have been added for some years. A number of the more recent Geological works have, however, now been purchased, and will, it is hoped, give an impetus to the use of the Library.

THE TRANSACTIONS are now printed up to the end of the last Session (1877-8), so that a considerable amount of leeway has been made up. The part containing the records of that and the previous session is now ready for issue, and the Council hope that the following part will bring the printing abreast of the work. Applications for exchange of publications with kindred societies still continue to be made, and on an increasing scale.

As on former occasions, the Council have to express their regret at the removal by death of various friends of the Society. Notable amongst the losses of the past Session is that of Dr. David Page, F.G.S., the well-known geological writer, whose connection with the Society was fully noticed by Mr. Wünsch at the meeting of last April. [See page 182.] The Council would here only record their sense of the loss which geological science has sustained. It may also be stated that the memorial stone to the memory of the late Dr. Bryce—the cost of which was subscribed for by members of this Society, the Edinburgh Geological Society, and the Inverness Naturalists' Field Club, has now been erected—and is said by those who have seen it to appropriately mark the sad locality.

It has not yet been found practicable to make any change in the place of meeting, but the Council have no doubt that before the lapse of another year proposals will be made by the Philosophical Society and the Society of Engineers for the accommodation of this Society, with other scientific bodies, in their new building presently in course of erection in Bath Street.

Mr. WIGHT read the Treasurer's Report, as follows:—

The anticipations indulged in by the Treasurer a year ago, that the Society's Balance-sheet on the present occasion would not present so favourable an appearance as that which was then furnished, have been happily not realized.

The net Stock of the Society at that time amounted to £147 1s. 5d., exclusive of publications, fossils, and casts; this year it amounts to £175 15s. 5d. Commercial disaster and bad times have not affected the Society a great deal. Its revenue from interest alone is equal to nine subscriptions. The total revenue last year was £117 12s. 11d.; this year it has been £110 12s. 10d. The falling-off has not been in new members, of which we had 12 this year and 13 last; neither strictly does it arise from ordinary subscriptions, which produced this year £96, and last year £96 10s. The difference is to be accounted for by a life subscription last year and payment of some arrears. The present membership is 210.

The funds of the Society seem to be gradually improving, and it is likely that by-and-by as much revenue may be obtained from invested funds as

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will equal the subscriptions which are lost by death, resignation, removal, and other causes. This is a point very desirable to be obtained.

The Treasurer's Financial Abstract will be found at page 306.

After both Reports were unanimously approved of, Mr. JOHN YOUNG, F.G.S., proposed a vote of thanks to the Treasurer and the Secretaries for the care and work they had bestowed on the conduct of the Society's business, and this was unanimously agreed to.

The CHAIRMAN then announced that the Council had come to the conclusion that the celebration of the majority of the Society should take the form of a supper.

Mr. MAYER proposed, and Mr. KIRSOP seconded, that this recommendation should be approved of, that the party should take place about the middle of December, and that the Council should be a Committee to make the necessary arrangements, which was agreed to unanimously.

The following gentlemen were elected to fill the vacancies in the list of Office-bearers :—Mr. John Young, F.G.S., Vice-President ; Messrs. David Robertson, F.L.S., F.G.S., Archd. Robertson, James Dairon, Daniel M'Millan, Thomas King, and James Neilson, jun., Members of Council—the first four being elected for three years, the fifth (Mr. King), in room of Mr. Young, for two years; and the sixth (Mr. James Neilson, jun.), in room of Mr. James Sommerville (retired), for one year. Mr. John Wight, C.A., was re-elected Treasurer; Messrs. R. Neilson and Joseph Sommerville, Librarians; Mr. J. B. Murdoch, Secretary and Editor of the *Transactions;* and Mr. Gavin Pratt, Joint-Secretary.

Mr. JAMES WHITE exhibited a series of Rocks and Minerals from Cornwall, on which he made some interesting remarks. [For an Abstract see page 217.]

Mr. DAVID ROBERTSON, F.L.S., F.G.S., read a paper "On the Occurrence of Mosses and Marine Algæ in the Glacial Clays at Garvel Park, Greenock." [As this paper will be incorporated with Mr. Robertson's more extended observations on the Garvel Park beds, it will be found in the next part of the *Transactions.*] The mounted specimens of Plant remains which were exhibited by Mr. Robertson in illustration of his paper showed the high state of preservation which they still retained after their long entombment in the soft clay, many of them being scarcely distinguishable in the details of their structure from recent specimens.

Mr. JOHN YOUNG, F.G.S., said that the identification of the seaweeds presented points of great interest, as the remains of algæ in the older and harder geological formations were not only rare, but when found were mere carbonaceous traces.

Mr. THOMAS STEEL made some remarks upon the appearances which presented themselves in the Garvel Park glacial clay-beds when they were dug into for organic remains.

It was agreed that an excursion for members to visit the locality at an early date should be arranged.

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4th DECEMBER, 1879.

Mr. JOHN YOUNG, F.G.S., *Vice-President*, in the Chair.

Messrs. Charles Edwards, Joseph Gentles, Crawford Jamieson, and Robert J. Wight were elected Ordinary Members.

The SECRETARY stated that the Council recommended that the Commemoration Supper should not take place until January, and this was agreed to, as also that some of the leading members of the Edinburgh Geological Society should be asked to be present.

Mr. THOMAS STEEL exhibited a Calcareous Nodule originally formed by segregation, and found as a boulder in the Post-tertiary clay of Garvel Park, Greenock. It was of unusual size, and showed well-marked glacial striæ, running in several directions along each of its flat faces. Calcareous segregations of similar character are still being formed in the river-bed from Port-Glasgow up to Bowling.

The CHAIRMAN referred to the chemical composition of such nodules, and said that they were found of many very curious forms in the brick-clays of Western Scotland, where they are known as "fairy-stones" and "crackers." They have been formed by a sort of chemical segregation of the lime and clay in the deposit, while its components were in a soft and unconsolidated condition. They are comparable to the nodules of clay-ironstone in the Carboniferous formation and flints in the Chalk formation, which in both instances have been formed in a similar manner. The present specimen was one of the largest he had ever seen, and had evidently been derived as a boulder from the denudation of some older bed of pre-glacial brick-clay before it was carried by the ice to the position in the Boulder-clay where it was found.

Dr. J. J. DOBBIE, M.A., D.Sc., read a paper "On the Occurrence of Euxenite and other Rare Minerals in the Veins of Graphic Granite at Hitterö, Flekkefiord, Norway," which locality he had visited in the course of last summer in company with Dr. W. Ramsay. [See p. 219.] The paper was illustrated by a series of splendid specimens, a suite of which, Dr. Dobbie stated, he had presented to the Hunterian Museum.

The CHAIRMAN spoke of the great interest which attached to many of the specimens exhibited by Dr. Dobbie, especially to those containing the elements of some of the rarer metals, as also to the geological conditions under which they occurred. The magnificent slab of Black Mica could only have been split from a crystal such as might have been read of in geological or mineralogical text-books, but which very few of the members could have been able to realise. It gave some idea of the crystallization of the elements of granite upon such a gigantic scale as is seldom or never seen in the granite veins of this country. The specimens of Graphic Granite were both interesting and instructive, as showing varieties intermediate between the true Graphic Granite and Pegmatite, and which he (Mr. Young) believed were varieties due to the abundance or rarity of one or other of the crystalline elements, Quartz and Felspar, and to the conditions under which they had

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cooled from igneous fusion. Mr. Young also stated that, however much the uninitiated may have been deceived in times past as to the true character of Graphic Granite, either as representing written rocks or organic structure, he hoped that that time had now passed away under the more advanced light of chemical knowledge, and the more especially so, as it was well understood that the mineral Felspar in its crystallized condition is never known in nature to replace organic structure in the same way as Silica or Calcite.

Mr. JOHN MAYER, F.C.S., Mr. JAMES THOMSON, F.G.S., and others, also made remarks on the subject.

15th JANUARY, 1880.

Mr. D. C. GLEN, F.G.S., *Vice-President*, in the Chair.

Mr. WIGHT reported the arrangements which had been made by the Council for the Commemoration Supper, which was to be held in the Alexandra Hotel, Bath Street, on the evening of Friday, 23rd instant.

Mr. Thomas Scott was elected an Ordinary Member.

Mr. DAVID ROBERTSON, F.L.S., F.G.S., exhibited a specimen of *Hyas coarctatus* from Post-tertiary clay, on which he made the following remarks:—During the excursion of the members to Garvel Park on 6th December, 1879, to the glacial clay-beds exposed in the excavations for the new docks there, Mr. Thomas Scott of Greenock, with his usual good fortune, exhumed a Crab belonging to the Brachyura, and generously committed it to my keeping. It was nearly perfect when found, so that there was no room for doubt of its identification as *Hyas coarctatus*. It was, however, so fragile that portions of the limbs and abdomen came away with the slightest touch of a moistened camel's-hair pencil, while the fracturing, when drying, of the clay in which it was embedded, bade fair to draw it to pieces, so that only with considerable difficulty it was kept together.

This species is common round our shores from low-water mark to a depth of 30 or 40 fathoms. In a table of measurements of sizes, taken at three stations, Mr. Adam White, in his "Popular History of British Crustacea," p. 23, gives the length of males of this species from Moray Firth, as 10 lines; from Sandgate, Kent, 1 inch 3 lines; and from Cumbrae, 1 inch 11 lines.

The specimen now exhibited was found deep down in the clay, enclosed between the valves of a *Pecten Islandicus*, and sitting as in life, probably where it had died, and not unlikely after a last repast on the remains of the mollusc whose shells afterwards supplied a sepulchre. Found under such circumstances, within the valves of one of our most characteristic glacial shells, we may reasonably assume that it had lived contemporaneously with the truly Arctic mollusca. The interest attaching to this find is that it is the first time, so far as I know, that any of the Brachyura, or Common Crab family, have been got in the Post-tertiary clays associated with Arctic

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shells, whereas remains of the Anomoura, or Hermit Crabs, are found in abundance.

Some years ago (12th April, 1877) I brought under the notice of the Society the presence of Hermit Crabs in the glacial clays, stating that "all the other crabs were rare, if not altogether absent from our seas during the deposition of the Post-tertiary clays." The fact, however, that this specimen has turned up in the clays—and even should one or two more be found, which is not unlikely—would only prove the exception to the rule. So far as is yet known, both the Brachyura and Macrura of our present seas are greatly in excess of their numbers during the deposition of the clays which contain Arctic shells; while on the other hand the Paguridæ, or Hermit Crab family, is as abundant in the clays as it is at the present time. Had species belonging to the two former families, such as the Edible Crab and Lobster, been as abundant during the period of the formation of the Arctic clays as they are now along our shores, their remains—so much larger and stronger generally than those of the Hermit Crabs—would have been very conspicuous, and could not have escaped notice until now. No better proof need be adduced in support of this statement than the large collection of Hermit Crab remains lately exhibited by Mr. Thomas Steel, of Greenock, to say nothing of the numbers in my own and other collections, contrasted with this single example before us, which is, as has been already stated, the first Brachyuran or Common Crab found in our Post-tertiary clays.

Mr. Robertson also exhibited tubercles of *Echinus Dröbachiensis*, and remarked that many of the organisms found in the Arctic clays have been lying so long under the action of the slowly-dissolving properties of their soft matrix that they come out beautifully dis-articulated, with other obscure connecting tissues disunited, which brings into view divisions of structure unattainable, perhaps, by any other means. The tubercles or bosses on which the spines of the echinidæ articulate (displayed on the tablet) show different states of detachment from the main plates of the test. They further demonstrate that the base of the tubercle is of independent growth, or, in other words, that the base of the tubercle is not homogeneously connected with the plate on which it rests, and can be separated from it by the dissolution of the connecting tissues. They come away from the test in little circular discs, and are made up of a succession of thin layers, one above the other, with a small tooth-like process in the centre on the under side, as it were to secure a firmer hold on the body plate. In cases where the tooth-like projection is broken off or eroded away a small pit or depression is left. The first or upper row on the tablet shows a partial separation of the tubercle plate from the test; the second row shows the tooth-like process on the under side of the disc; the third row shows the layers of the disc and the scars and depressions of the eroded tooth-like processes; while the fourth row shows the articulating crowns of the tubercles.

Mr. Thomas Scott and Mr. Thomas Steel also remarked upon the subject.

Mr. John Kirsop exhibited a number of cut specimens of Corals, &c., from Devonshire and other localities.

Mr. James C. Christie exhibited a number of specimens of Labradorite,

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Fluorspar, &c., and made some remarks upon the peculiarities of their occurrence. He also showed specimens of Fibrous Gypsum, from strata of the upper coal measures, cut through in sinking a new coal-pit shaft near Hamilton.

Mr. JOHN YOUNG, F.G.S., read a paper entitled "Notes on some Carboniferous Lamellibranchs. Their Mode of Occurrence, and observed Shell-structure." [See page 223.]

Mr. JAMES THOMSON, F.G.S., made some remarks on the points taken up in Mr. Young's paper.

12th FEBRUARY, 1880.

Mr. DAVID SANDEMAN, *Vice-President*, in the Chair.

The death of Mr. Matthew Forsyth, a Member of the Society since 1872, was mentioned by the Secretary; and the Chairman spoke of the loss sustained by their friend and vice-president, Mr. D. C. Glen, in the death of his wife, and moved that the Secretary should be instructed to express the sincere sympathy of the members with Mr. Glen and his family in their bereavement. This was seconded by Mr. John Young, F.G.S., and cordially agreed to.

Mr. ALAMETH COULTHURST exhibited a number of Laminated Nodules from the Paisley clay-beds, and described their position and occurrence, Mr. YOUNG also making some remarks on the subject.

Mr. JOHN KIRSOP exhibited a beautiful slab of Chalcedony with amethysts, and a Nodule of Chert with crystals of carbonate of lime.

Dr. J. R. M. ROBERTSON, F.R.G.S., read a paper on "The Oil and Oil-Wells of Burma, with Notes on the Geology of the Districts of their Occurrence." [See page 226.] It was fully illustrated by a large series of maps, diagrams, and specimens of oil-bearing rocks and their products.

Mr. YOUNG and Dr. J. J. DOBBIE made some remarks on the subject of Dr. Robertson's paper.

11th MARCH, 1880.

Mr. DAVID SANDEMAN, *Vice-President*, in the Chair.

Messrs. Neil M'Kechnie, John Henderson, and David Riddell were elected Ordinary Members.

Mr. JAMES WHITE exhibited a specimen of Metamorphosed Lime, taken from the back of a fire-place where it had been exposed to great heat, and showing columnar structure and layers of foliation.

Mr. JOHN YOUNG, F.G.S., said that the specimen was a very remarkable one, and that he had never seen anything like it before.

Mr. JOHN KIRSOP exhibited specimens of Granular Sulphate of Lime from the banks of the Suez Canal; Banded Stalagmite from Italy; Coralline Limestone from Iowa (a splendid specimen); and a Tooth of *Rhizodus Hibberti* from Possil.

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Mr. DAVID ROBERTSON, F.L.S., F.G.S., read a paper "On a Series of Foraminifera and Ostracoda from a Post-tertiary Deposit in Lewis," which, with the exception of the bed at Chapelhall, Airdrie, is the highest at present known in Scotland. [See page 248.]

Mr. YOUNG and Mr. JAMES THOMSON, F.G.S., made some remarks on the subject.

Mr. ROBERTSON also exhibited a bivalve shell new to Scottish glacial deposits, *Leda frigida*, Torell, which had been lately found in the Post-tertiary clay at Garvel Park, Greenock.

Mr. MURDOCH read a paper, forwarded by Prof. Edward Hull, F.G.S., Director of H.M. Geological Survey of Ireland, entitled "Reply to Remarks by Mr. John Young, F.G.S., on Prof. Hull's Proposed Triple Division of the Carboniferous Strata," &c. [See page 250.]

Mr. YOUNG said that there was a slight mistake in the statement that his remarks were founded upon the short abstract of Prof. Hull's paper as read before the Geological Society of London on 25th April, 1877. The fact was that his criticism was based upon Prof. Hull's paper read to Section C of the British Association at Glasgow in September, 1876, and it was brought up before this Society on 7th December, 1876, and therefore long anterior to the publication of the abstract referred to. Mr. Young further said that his remarks were not made so much to find fault with Prof. Hull's proposed Triple Classification of the Carboniferous strata of Great Britain and Ireland as to point out to the members that a classification founded on a palæontological basis for England and Ireland would not suit Scotland, especially for the limestone series, to which his paper more particularly referred, and to which Prof. Hull's first three stages—A, B, and C—belong. It is in these stages in Scotland that we find the greatest diversity in the flora and fauna of the several strata, which clearly shows that they must have been accumulated under different physical conditions from those of England and Ireland, He had carefully read Prof. Hull's later paper to the Geological Society of London, but he had failed to find in it any further evidence of a palæontological character which would help to establish a more uniform set of conditions between the Scottish limestone series and those of England and Ireland. Prof. Hull admits the fact that in stage C of the limestone series of Scotland we have fresh-water and estuarine beds, but in his present paper [see page 251] he says that stage B of the limestone series is "everywhere of marine origin." This is not the case as regards the Western Scottish coal-fields, as Prof. Hull himself ought to know. He should have been aware that in stage B of the limestone series there occur, in several horizons of the group, beds of estuarine and fresh-water strata, which contain nearly the whole assemblage of organisms characterising stage C and the fresh-water stages F and G. Mr. Young said that he would not at present go into detail about the fresh-water strata in stage B or their contained organisms, as various papers already published in the *Transactions* contain them, but would merely state that the longer the organisms of the Carboniferous lacustrine strata were investigated, and their true nature better understood, the more clearly did they testify to the differences in the physical conditions under which stages A, B, and C of the Scottish

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limestone series had been deposited. These strata consist of numerous alternations of land surfaces, with lacustrine and marine conditions, their physical changes also altering and bringing about the varied forms of life which characterise the limestone strata of Scotland in all their stages. In England and Ireland, on the other hand, the conditions under which the limestone series were deposited seem to have been much more uniform, and to have been chiefly of a marine character, as indicated by their fossils. He was afraid that Prof. Hull, in his laudable endeavour to correlate the limestone series of Scotland upon a palæontological basis with that of England and Ireland, had assumed a somewhat similar uniformity of condition for our limestone strata, in a series of deposits in which no long-continued uniformity seems ever to have existed, as is clearly testified by the varying groups of terrestrial, lacustrine, and marine organisms which the strata contain.

Mr. JAMES THOMSON, F.G.S., also spoke, agreeing with Mr. Young that Prof. Hull's position was untenable.

Mr. JAMES C. CHRISTIE read a paper entitled "Notes on the Hohentwiel, a Volcanic Cone in the South of Wurtemberg," which he had visited last summer. [See page 254.] The paper was illustrated by a number of specimens from the district under review.

2nd APRIL, 1880.

Sir WILLIAM THOMSON, LL.D., F.R.S., &c., *President*, in the Chair.

Messrs. Alexander Rae, John H. M. Park, John B. Sommerville, and Robert Frame were elected Ordinary Members.

Mr. CHARLES LAPWORTH, F.G.S., St. Andrews, read a paper upon "Graptolites" [for an Abstract, see p. 260], illustrating his subject with a large and fine series of diagrams and figures.

The CHAIRMAN (Sir William Thomson) said that, without any special knowledge of the subject to guide him, he had listened to Mr. Lapworth's paper with the utmost interest, and he was sure that the clear and masterly way in which the family of Graptolites had been described must also have struck every one of the members who had been privileged to be present on the occasion.

Mr. JOHN YOUNG, F.G.S., Mr. E. A. WÜNSCH, F.G.S., and Mr. DAIRON also made some remarks upon the subject.

22nd APRIL, 1880.

Mr. D. C. GLEN, F.G.S., *Vice-President*, in the Chair.

Messrs. E. S. Nisbet and F. W. Grierson were elected Ordinary Members.

Mr. JOHN YOUNG, F.G.S., exhibited a number of rare Minerals, including Basanite, Millerite, and Niccolite, from Newfoundland—the CHAIRMAN

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(Mr. D. C. Glen) and Dr. J. J. DOBBIE making some remarks upon the specimens.

Mr. MURDOCH read a paper forwarded by Mr. THOMAS STEEL, entitled "Notes on a Fossiliferous Post-pliocene Bed at Gourock." [See page 261.]

The SECRETARY also read a paper forwarded by Mr. T. MELLARD READE, C.E., F.G.S., of Liverpool, "On the Relations of the Glacial Deposits of the Clyde and Forth to those of the N.W. of England and N. of Ireland." [See page 264.]

From the lateness of the hour, any discussion on Mr. Reade's paper was held over until the following Meeting.

13th MAY, 1880.

Mr. D. C. GLEN, F.G.S., *Vice-President*, in the Chair.

Dr. Dougan, Messrs. J. W. Knox, A. M'Dougal, and A. Young, were elected Ordinary Members.

The CHAIRMAN announced that a Joint Excursion with the Edinburgh Geological Society had been definitely fixed for the 26th June prox. to Beith, Ayrshire, under the guidance of Mr. Robert Craig, Langside, Beith, and that, on the return of the party, the Members of the Society would entertain their Edinburgh friends to dinner in the Cobden Hotel, Argyll Street.

Mr. THOMAS STEEL exhibited a number of Diatoms from the London Clay, which he had received from Mr. Shrubsole, of Sheerness-on-Sea.

Mr. JAMES STEWART exhibited two specimens of Black Tourmaline from Rubislaw, and a fine specimen of Red Stilbite from the neighbourhood of Dunottar.

Mr. JAMES COUTTS exhibited a number of fossils from the Carboniferous limestones of East Kilbride, principally Crustacean remains, and one of them being new to the West of Scotland, if not new to science. These specimens had been found by Mr. Andrew Paton, of the Cement Works, East Kilbride, in whose cabinet they were. The undescribed specimen had been submitted to Mr. Peach, who suggested the name *Palæocaris?*

The adjourned discussion on Mr. Mellard Reade's paper "On the Relations of the Glacial Deposits of the Clyde and Forth to those of the N.W. of England and the N. of Ireland," was taken up, after the Secretary had read a short *resumé* of it.

Mr. JOHN YOUNG, F.G.S., Mr. DAVID ROBERTSON, F.L.S., F.G.S., Mr. DAIRON, and other members, agreed generally with the writer's conclusions —Mr. Young remarking that he could not endorse the statement that all Scottish geologists accepted Prof. Arch. Geikie's view that the Scottish Till was a *moraine profonde*.

The Society then adjourned until the commencement of the following session in October next.

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Abstract of the Treasurer's Accounts for Year ending 30th September, 1878.

REVENUE.

RECEIPTS.							DISBURSEMENTS.						
Balances due by Treasurer at close of last Account,	£0	12	8				Printing *Transactions*,				£49	7	4
Do. by Librarian at do.,	0	9	11	£1	2	7	Do. Syllabus, Circulars, &c.,				10	13	3
Subscriptions—Arrears for 1873-74, 1874-75, and 1875-76, one member,	1	10	0				Rent, Gas, Insurance, and Attendance,				13	13	6
Do. for 1876-77, 3 at 10s.,	1	10	0				Subscription for *Geological Record* (3 years),				1	11	6
Subscriptions for current year, 193 at 10s.,	96	10	0				Reporting Sir Wm. Thomson's Address,				2	2	0
New Members, 13 at 10s.,	6	10	0	106	0	0	Collector's Commission, Postages, and Petty Expenses,				6	13	3
Life Subscription,				5	0	0	Delivering *Transactions*,				3	0	0
Publications sold,				3	4	0	Disbursements by Secretary,				5	19	5
Interest on Bank Account,	1	7	3				Do. by Librarian,				2	9	6
Do. on Loan, Corporation of Glasgow,	1	16	8	3	3	11	Lodged in Bank,				94	0	9
Drawn from Bank,				172	13	6	Lent to the Corporation of Glasgow,				100	0	0
							Balances—Due by Treasurer,	£0	14	1			
							Due by Librarian,	1	4	5	1	18	6
				£291	9	0					£291	9	0

STOCK.

Sundry Liabilities,				£18	8	1	Cash Lent to the Corporation of Glasgow,				£100	0	0
Balance to Credit,				322	1	5	Cash in Bank on Deposit Receipt,	£51	2	7			
							Do. on Account Current,	12	8	5	63	11	0
							Cash in Treasurer's hand,	0	14	1			
							Do. in Librarian's hand,	1	4	5	1	18	6
							Publications, Fossils, and Casts,				175	0	0
				£340	9	6					£340	9	6

LIFE SUBSCRIPTION ACCOUNT.

1878.—Sept. 30. To Balance to Credit,	£105	0	0	1877.—Oct. 1. By Subscriptions to date,	£99	15	0
				1878.—Apl. 18. Dr. Gilmour,	5	5	0
	£105	0	0		£105	0	0

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Abstract of the Treasurer's Accounts for Year ending 30th September, 1879.

REVENUE.

RECEIPTS.

Balances due by Treasurer at close of last Account,	£0	14	1			
Do. by Librarian,	1	4	5	£1	18	6
Subscriptions—Arrears for 1877-78, 3 at 10s.,	1	10	0			
Subscriptions for current year, 182 at 10s.,	91	0	0			
New Members, 12 at 10s.,	6	0	0	98	10	0
Subscription from a Friend,				5	0	0
Publications sold,				2	14	6
Interest on Bank Account,	0	10	0			
Do. on Loan to Corporation of Glasgow,	3	18	4	4	8	4
Drawn from Bank,				63	15	4
				£176	6	8

DISBURSEMENTS.

Engraving, Woodcutting, &c.,				£11	3	0
Printing Syllabus, Circulars, &c.,				14	0	3
Subscription to Palæontographical Society (2 years),				2	2	0
Rent, Gas, Insurance, and Attendance,				13	17	1
Collector's Commission, Postages, and Petty Expenses,				5	6	4
Carriage of Parcels,				1	1	7
Disbursements by Secretary,				4	14	11
Do. by Librarian,				1	7	0
Lodged in Bank,				120	1	11
Balances—Due by Treasurer,	£0	0	8			
Due by Librarian,	2	11	11	2	12	7
				£176	6	8

STOCK.

Current Liabilities,				£46	14	9
Balance to Credit,				350	15	5
				£397	10	2

Cash Lent to the Corporation of Glasgow,				£100	0	0
Do. in City of Glasgow Bank,	£31	17	7			
Do. in British Linen Co. Bank,	88	0	0			
Do. in Treasurer's hands,	0	0	8			
Do. in Librarian's hands,	2	11	11	222	10	2
Publications, Fossils, and Casts,				175	0	0
				£397	10	2

LIFE SUBSCRIPTION ACCOUNT.

1878.—Oct. 1. By Balance,				£105	0	0

GLASGOW, *10th November, 1879.*—I have examined the foregoing Account, and compared the same with the Vouchers, and find it correctly stated and sufficiently vouched, the balance in Treasurer's hands at 30th September last being Eightpence sterling.

(Signed) JAMES WHITE, AUDITOR.

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